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THE EFFECT OF WATER LEVELS ON LARCH SAWFLY POPULATIONS*

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I INTRODUCTION

Cocoons of the larch sawfly normally spend from nine to ten months in the ground per annum under conditions existing in western Canada. For this reason biotic and abiotic soil factors are of paramount importance in the epidemiology of this insect. Preliminary observations and experiments indicate that ground water is one of the most important of these factors in that it not only affects sawfly development directly but also is significant in regulating sawfly predators and possibly parasites.

There appear to be two opposing points of view respecting the influence of water levels in the control of the larch sawfly. S. A. Graham (1) concluded from his studies that draining swamps tends to create a favourable habitat for small mammals which prey upon larch sawfly cocoons whereas A. R. Graham (2) implied that, generally speaking, defoliation is less severe in wet swamps. Undoubtedly both views might apply under certain differing local conditions. This study was initiated to evaluate more precisely the influence of ground water on larch sawfly populations.

If it is demonstrated that under field conditions submergence of the cocoons in water can and does regulate sawfly populations, the information will be of value ecologically in interpreting and predicting larch sawfly trends. From the practical standpoint the manipulation of water levels might be used to control sawfly populations under certain limited conditions.

The study was initiated as a definite project in September, 1946, with several phases proposed for immediate investigation. These were: (1) the sawfly stages and periods most susceptible to submergence in water, (2) the period of submergence required to produce death, (3) sawfly cocooning habits in relation to water levels, (4) influence of submergence on diapause, (5) influence of flooding on growth of tamarack and (6) feasibility of flooding and draining swamps.

Because this problem has been under investigation for a short time only, this paper is in the nature of a progress report and makes no pretence of providing answers to all the above questions. Nevertheless it is felt that sufficient information has been obtained on the first two phases of the investigation to indicate something of the nature of the relationships involved.

II METHODS

The effects of submergence were investigated under three sets of conditions; (1) controlled laboratory conditions, (2) known but uncontrolled field conditions and (3) natural field conditions.

The effects of submergence on sawfly development were determined by cocoon dissections supplemented by rearings where necessary. The developmental stage attained by a sawfly at the time its cocoon was opened was described in every case. The terms employed by Prebble (3) in his studies on the diapause of the European spruce sawfly were adopted. While his

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morphological descriptions do not correspond exactly with those occurring in the larch sawfly, analogous eonymph and pronymph phases were recognized.

The controlled laboratory study required the storage of cocoons for definite periods of time under known moisture conditions. Wooden frames 3½ inches deep covered with galvanized screen wire on the top and bottom were constructed. Two hundred cocoons were placed between an upper and a lower layer of sphagnum moss in each frame. The frames were then placed in individual metal pans to which water could be added or removed as required.

Cocoons in frames were subjected to the following treatments; (1) dry at all times, (2) submerged at all times, (3) submerged during the fall and winter and dry in the spring, and (4) dry in the fall and submerged in the spring. Duplicate frames in separate pans were used for each treatment. The term 'dry' in referring to treatments may be somewhat misleading. Actually the intention was to provide conditions known to favour sawfly development, and some moisture was added to the moss occasionally to prevent dessication. The frames were stored in an open air insectary throughout the course of the experiment.

For the second experiment similar but larger frames, each 1 foot square and containing 200 cocoons, were buried in pits dug in two swamps at Riding Mountain National Park, Manitoba, on September 23, 1946. The pits were 18″ square and excavated to a depth well below water level. A marker was driven into each pit for the purpose of recording the water fluctuations. The water level at the time the frames were buried was arbitrarily selected as zero. Five frames were then tiered in each pit in such a manner that cocoons were at depths of 6 inches and 3 inches below water level, at water level and at 3 inches and 6 inches above water level. Pits were constructed in two swamps, and in each swamp duplicate sets of five frames were buried in adjacent pits.

Series of 20 cocoons were removed from each frame in the laboratory and field experiments at intervals of one month for dissection and rearing. No removals, however, were made during the winter months when the ground was frozen. The condition of the sawflies was recorded using the terms dead, alive or doubtful. When doubtful individuals were encountered an additional sample of cocoons was reared for 7 days at room temperature and at high humidity. These conditions were provided for the purpose of stimulating larval activity to permit the classification of doubtful larvae as either dead or alive. It is felt, however, that this rearing test for doubtful larvae was not entirely satisfactory, and it seems that a more precise biological test to detect living larvae could be advantageously employed.

As a check on the above experiments cocoons lying both above and below the water line under natural field conditions were collected and dissected during the summer of 1947. Five areas were sampled and 20 cocoons above and below the water level were removed at each sampling. Collections were made on May 20, June 2, June 8, June 18 and June 26, making a total of 300 cocoons dissected from this source. Unfortunately no records of water fluctuations are available for the sites examined and therefore the periods of submergence of these cocoons are not known.

III RESULTS

Table 1 summarizes the results obtained from the controlled laboratory studies. Due to the difficulty of interpreting results from the two sources, dissection and rearing, and inasmuch as the two techniques were employed for the same end, namely to distinguish living from dead sawflies, the data

from dissections and rearings have been condensed into two columns, % dead and % living. When the dissections indicated beyond doubt that the individuals examined were either dead or alive, the dissection figures were used in table 1. However, when doubtful larvae were encountered, an additional series of cocoons was reared and data secured from the rearings were then used to express sawfly mortality. The same procedure was followed in table 3.

TABLE I

MORTALITY AND DEVELOPMENT OF LARCH SAWFLY COCOONS SUBJECTED TO FOUR CONTROLLED WATER TREATMENTS

Examination dates	Treatment*	Submerged period (days)	% dead	% alive	Phase of dead sawfly	Phase of living sawfly
Oct. 25 1946	A	0	0	100	—	eonymph
	B	30	0	700	—	"
	C	30	0	100	—	"
	D	0	0	100	—	"
May 12, 1947	A	0	0	100	—	2 pupae 38 conymphs
	B	244	100	0	eonymphs	—
	C	228	100	0	"	—
	D	16	85	15	"	eonymph
June 12 1947	A	0	0	100	—	5 pupae, 35 conymphs
	B	275	100	0	eonymph	—
	C	228	100	0	"	—
	D	47	92	8	"	pronymph
July 17, 1947	A	0	30	70	adult**	8 pupae, 20 adults
	B	310	100	0	eonymph	—
	C	228	100	0	"	—
	D	32	100	0	"	—
Aug. 12. 1947	A	0	100**	0**	20 conymphs** 20 adults	—
	B	336	100	0	eonymph	—
	C	228	100	0	"	—
	D	108	100	0	"	—
Sept. 12 1947	A	0	35	65	"	adults
	B	367	100	0	"	—
	C	228	100	0	"	—
	D	139	100	0	"	—

* A-dry at all times; B-submerged at all times; C-submerged fall and winter, dry in spring; D-dry in fall, submerged in the spring and summer.

** Development normal but mortality apparently due to dessication.

The first dissection of cocoons on October 25, 1946, 30 days after commencing treatment, yielded no dead larvae. Those which had been submerged were inactive, but the larvae from an additional series became quite active after a rearing period of seven days. This indicates that more than one month of submergence in the fall is required to kill the larvae.

Freezing weather following this inspection and formation of ice in the containers holding submerged cocoons prevented further examination until the following spring.

The next examination, made on May 12, 1947, 244 days after treatment commenced, showed complete mortality of the larvae in cocoons which had been submerged during the fall and winter. Those receiving the submergence treatment in the spring had been under water for 16 days prior to dissection. The larvae from these cocoons were classified as doubtful, and, upon rearing, 15% of the larvae in cocoons recovered. Complete survival of larvae from cocoons stored under dry conditions was recorded.

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On June 12 an 8% survival of larvae in cocoons that had been submerged since April 26 was recorded, but by July 17 all the larvae in this category had died. The sawflies in cocoons which were stored under dry conditions developed normally throughout the summer.

Both continuous and fall through winter submergence had the effect of arresting development of the larvae, since none subjected to this treatment passed beyond the eonymph stage. Some of those submerged in the spring were able to develop to the pronymph stage before dying whereas, under dry conditions, normal development of the larvae proceeded.

In the field experiment it was the intention that buried frames should receive various water treatments, some submerged continuously, some intermittently, and others not at all. Unfortunately excessive rains followed the burying of the frames, and interfered with these plans. Owing to the subsequent high water levels in the tamarack swamp, 12 frames were submerged continuously, 6 intermittently and only 2 were above the water level continuously except for a period of from 10-14 days in May, 1947.

This experiment is being repeated under slightly different conditions which will permit greater control to be exercised over the periods of submergence.

Table 2 indicates the fluctuations of water levels above the zero marks in the two experimental plots. In inspecting this table it should be remembered that a height of 6 inches or more above the zero level effects complete immersion of all cocoons.

TABLE II

FLUCTUATIONS OF WATER LEVELS IN EXPERIMENTAL PLOTS DURING STUDY PERIOD

Date	No. of Days	Heights above original level in inches Golf Course Pit A	Pit B	Mi. 7 Norgate Road Pit C	Pit D
Sept. 23, 1946	0	0.0	0.0	0.0	0.0
Oct. 18, 1946	25	6.5	6.5	3.0	3.0
Nov. 14, 1946	52	5.5	5.5	2.5	2.5
May 12, 1947	231	7.0	7.0	5.5	6.0
June 11, 1947	261	7.0	6.0	4.0	3.0
July 16, 1947	296	4.0	4.0	0.5	2.0
Aug. 12, 1947	323	2.0	2.0	1.0	1.0
Sept. 11, 1947	353	1.5	1.5	0.5	0.0

Table 3 provides a summary of results from the four replicated sets of frames buried in pits at Riding Mountain National Park. The immersion treatments are here classified as continuous, intermittent and above water continuously except for a short period. In view of the slightly different classifications employed, the results are not completely comparable with corresponding treatments in the laboratory study.

TABLE III

MORTALITY AND DEVELOPMENT OF LARCH SAWFLY SUBJECTED TO KNOWN SUBMERGENCE UNDER FIELD CONDITIONS

Examination dates	Treatment*	Submerged period (days)	% dead	% alive	Phase of dead sawfly	Phase of living sawfly
Oct. 18 1946	A	0	0	100	—	eonymph
	B	25	0	100	—	"
	C	5-16	0	100	—	"
Nov. 14 1946	A	0	0	100	—	"
	B	52	0	100	—	"
	C	5-39	0	100	—	"
June 11 1947	A	10-14	15	85	eonymph	4 pronymphs 2 pupae 28 eonymphs

	B	261	100	0	eonymph	—
	C	5-197	90	10	"	eonymph
July 16	A	10-14	70	30	"	"
1947	B	296	100	0	"	—
	C	5-197	85	15	"	eonymph
Aug. 12	A	10-14	100	0	"	—
1947	B	323	100	0	"	—
	C	5-197	95	5	"	eonymph
Sept. 11	A	10-14	100	0	"	—
1947	B	353	100	0	"	—
	C	5-197	100	0	"	—

• A — above water continuously except for 10-14 days in May, 1947;
B — continuous submergence;
C — intermittent submergence.

On the whole the results of the field study parallel those obtained from the laboratory experiment. In the field study no larval mortalitiy resulted in the fall from fall submergence, but at the time of the first spring examination on June 11, 1947, all the larvae in cocoons which had been continuously submerged had died in the eonymph stage. Similar results were obtained in the laboratory study, but it should be noted that the examination of field cocoons was made about one month later due to the difficulty of removing cocoons from the frozen moss.

A 100% survival of sawflies in cocoons intermittently submerged and of those above water for a continuous period was recorded throughout the fall examinations. In the following spring, however, significantly different survivals were in evidence, with those above water for a continuous period showing by far the highest percentage living in June, but only a slightly higher survival in July. Surprisingly, by August all the sawflies in cocoons above water for a continuous period had succumbed, while 5% of the larvae from cocoons intermittently submerged were alive. By September all the sawflies in cocoons submerged intermittently were dead.

Larvae in cocoons immersed intermittently did not progress beyond the eonymph stage, but some unexpected findings were recorded from those above water for a continuous period. On June 11, 4 pronymphs and 2 pupae were observed, while in succeeding examinations no development beyond the eonymph stage was recorded. One explanation may be that most of the cocoons remained in diapause, and only those which had developed beyond the eonymph stage completed metamorphosis during June and early July. If, after that time, only cocoons in diapause remained in the frames, no development beyond the eonymph stage could be expected. Perhaps if this is so, diapause was induced or continued by excessive moisture.

No sawfly mortality was recorded in the third phase of this study involving the examination of cocoons removed from their natural cocooning positions in the moss of tamarack swamps. However, while the larvae in cocoons collected above water level developed normally through the pronymph, pupal and adult stages, the larvae in submerged cocoons apparently remained in diapause in the eonymph stage throughout the period of the examinations. The important point is that under natural conditions immersion during some period of the spring and summer is not necessarily lethal. It should be remembered, however, that the length of submergence of these cocoons under water is unknown, and it would appear to be desirable to investigate thoroughly the resistance of the larch sawfly to submergence under field conditions as opposed to experimental conditions.

IV DISCUSSION AND CONCLUSIONS

Indications are that larvae in cocoons are resistant to submergence during the fall, as in one series so treated no mortality had occurred after an immersion period of 52 days. The effect of fall immersion only, on

subsequent mortality in the spring, has not yet been tested. If fall immersion is continued throughout the winter months, complete sawfly mortality is effected by the following spring under experimental conditions.

The sawfly larvae appear to succumb most quickly under experimental conditions to spring and summer submergence during the period when larvae are normally undergoing metamorphosis. Perhaps this crucial period can be more precisely established. It seems natural to suppose that the sawfly may be more susceptible to immersion at this time due to its higher oxygen requirements for metabolic processes.

Continuous submergence resulted in complete mortality of the larch sawfly larvae, but in practice such conditions are not often encountered in the field nor would continuous controlled flooding be desirable from the standpoint of tree growth.

The most favourable conditions for sawfly development were those referred to as 'dry' throughout this paper. These conditions would be similar to those obtained in well drained tamarack stands.

It is evident from the results obtained to date that under certain experimental conditions, immersion in water is lethal to larch sawfly larvae in cocoons. It is also apparent, however, that as experimental conditions approach natural field conditions, the chances of surviving immersion are appreciably improved. It is difficult, nevertheless, to draw a parallel between the results of the treatments to which cocoons were subjected inasmuch as the periods and conditions of submergence were not always comparable.

Numerous records of defoliation in relation to water levels in swamps, compiled by the Winnipeg Laboratory, show that sawfly abundance, as reflected by defoliation, is often at variance with the experimental results. On the whole, trees growing in dry sites experienced the lowest defoliation. Sites classified as 'moist' showed the highest defoliation of tamarack while those termed 'wet' fell in between the other two. It may be that a further subdivision of the classification 'wet sites' is desirable because many of those now so designated are possibly borderline cases which might more correctly be classified as moist sites.. Another discrepancy might have been introduced by the fact that water levels prevailing during the crucial period of sawfly metamorphosis in the cocoons are not necessarily the same as those obtaining at the time defoliation is recorded later in the season. More reliable information can be procured by following the progress of sawfly development and variations in the defoliation and water levels in selected tamarack swamps.

This preliminary work has indicated the considerable complexity of the problem. It has shown the need for determining the effect of a number of possible variations in water levels, alone and in combination with other physical factors, on sawfly mortality, develpment, diapause, cocooning habits, physiological processes, biotic potential and sawfly parasites and predators. For the sake of brevity these are not elaborated upon here.

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LABORATORY ASSESSMENT OF ORGANIC INSECTICIDES FOR CONTROL OF CERTAIN LEPIDOPTEROUS LARVAE

BY

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Recent developments in the insecticide field have made available to the economic entomologist a wide variety of chemical compounds which exhibit high toxicity to certain species or groups of insects. The pyrethrins, rotenone and nicotine, reinforced by the dinitro compounds and thiocyanates of prewar times, have now been joined by the chlorinated aromatic hydrocarbons: DDT, gammexane, chlordane and toxaphene.

In order to discover which of this array of compounds were likely to be most effective against the group of insect pests included under lepidopterous larvae, 15 of the insecticidal compounds now in production were tested against larvae of the Pale Western Cutworm (*Agrotis orthogonia* Morr.), the Flax Bollworm (*Heliothis ononis* Schiff.), and the Spruce Budworm (*Cacoecia fumiferana* Clem.). The compounds were dissolved in oil and sprayed in various concentrations on the larvae in a spray tower. Thus only their direct contact effect was assessed as an index of their toxicity.

MATERIALS

The compounds to be tested were obtained in as pure a form as possible. The majority had been purified by recrystallization or distillation in the laboratory. However, certain compounds could be obtained only in technically pure form from the manufacturers and others were available only as solutions of a specified percentage strength.

The following compounds were tested for their toxicity to these lepidopterous larvae:

(a) DDT: purified crystalline p,p'-dichloro-diphenyl-trichloroethane, m.p. 108-109°C.

(b) Gammexane: purified crystalline gamma isomer of s-hexachlorocyclohexane (benzene hexachloride), m.p. 112.5°C.

(c) Chlordane: purified by double distillation of Technical 1068 (Velsicol Corporation).

(d) Toxaphene: technically pure octachloro-camphene (Hercules Powder Company).

(e) DNOC: purified crystalline 4,6-dinitro-o-cresol (also termed 3,5-) m.p. 85.8°C.

(f) DNOCHP: purified crystalline 2, 4-dinitro-6-cyclohexyphenol, m.p. 104-5°C.

(g) Lethane 60: commercial product containing 50 per cent thiocyanoethyl laurate in kerosene (Rohm and Haas).

(h) Lethane 384: commercial product containing 50 per cent B-butoxy-B'-thiocyanodiethyl ether in kerosene. (Rohm & Haas).

(j) Thanite: commercial product containing bornyl thiocyanoacetate with tertiary terpine alcohols. (Hercules Powder Company).

(k) Azobenzene: crystalline, white label (highest purity) (Eastman Kodak Company).

(l) Methoxy-DDT: technical grade of p,p'-dimethoxy-diphenyl-trichloroethane (Dupont Experimental Station).

(m) Hexaethyl tetraphosphate: technical grade, containing also a substantial percentage of tetraethyl pyrophosphate. (Eston Chemicals).

(n) Pyrethrins: commercial product (Pyrefume Super 30) containing 3 per cent pyrethrins in kerosene (S. B. Penick & Co.).

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(o) Rotenone: purified crystalline compound, m.p. 162.6° - 163.1°C.
(p) Nicotine: alkaloid, white label (highest purity) (Eastman Kodak Company).

The compounds were dissolved in a mixture of 4 parts by volume of benzene and 1 part odourless kerosene for spraying. The kerosene was added to the solvent in order to reduce the volatility of droplets in the spray.

The *Agrotis* material consisted of pale western cutworm larvae collected from the soil of an infested grain field at Welling, Alberta on 15 May 1947, and kept at 73°F in individual salve tins while being fed on young wheat foliage. The testing was carried out 1 to 2 weeks after collection, when the larvae were in the 4th, 5th and 6th instars. No parasitism could be detected in this material.

The *Heliothis* material consisted of flax bollworm larvae collected from infested flax fields at Tyner, Sask. on the 10th and 13th August 1946, and kept in a room air-conditioned at 70°F. and 70% R.H. while being fed on fresh flax. The testing was carried out 1 to 5 days after collection, when the larvae were in the 4th, 5th and 6th instars, as determined by micrometer measurement of head capsules. The degree of parasitism of these larvae was approximately 2 per cent.

The *Cacoecia* material consisted of spruce budworm larvae collected on spruce brush in the Spruce Woods Reserve, Manitoba, on 28th May 1946, and kept in a refrigerator at 34°F and later in a room air-conditioned at 70°F. and 70% R.H. until needed for use. The larvae, when employed in the tests, were in the 4th and 5th instars. Approximately 4 per cent parasitism was noted in these larvae.

METHODS:

The insecticidal compounds were dissolved in the benzene-kerosene mixture and were sprayed on to the larvae in a cylindrical glass spray tower, measuring 29 inches high by 12 inches internal diameter. The methods followed were in general similar to those described by Tattersfield and Morris (1924) and by Busvine (1945). The spray was applied by a DeVilbiss Special Atomizer No. 631 centrally placed in the lid of the cylinder, and operated at an air pressure of 23 cms. Hg controlled by a reducing valve and accurately measured by a manometer.

The spray solution was introduced from a 10 cc burette into the aspirator attachment of the atomizer, passing through a capillary constriction at the rate of 7 cc. per minute. The room in which spraying was performed was kept at a temperature of 75° to 80°F. and a relative humidity of over 75 per cent, in order to reduce the electrostatic charges generated in the tower. Under these conditions, 4 cc. of spray solution was found to yield an average deposit at the base of the cylinder of approximately 4 cu. mm. of solution per square centimetre. Thus where 8 per cent solutions were employed, the density of deposit of the dissolved compound would be 320 gamma per square centimetre. In terms of field use this would be equivalent to a deposit of approximately 30 pounds of dissolved compound per acre.

The spray was allowed to settle for 1½ minutes. The size of droplets was assessed by exposing microscope slides coated with the silicone preparation G.E. Dri-Film 9987, and measuring them under the compound microscope, making allowance for the factor of spread of the droplets on this surface. By this method, the droplets in the spray were found to range between 5 and 90 microns in diameter, and the median diameter by mass was approximately 60 microns.

The larvae for test were placed in a crystallizing dish measuring 2½ inches high and 4¾ inches in diameter, and fitted with a floor of filter paper. The dish was centred at the base of the spray tower so that the larvae were 28 inches below the atomizer nozzle. In the case of *Agrotis*, 10 larvae were used in each test; for *Heliothis* and *Cacoecia*, 20 larvae were employed per test.

Each test at a given concentration of each insecticide was performed in duplicate. The series of sprays with each insecticide was commenced using 4 cc. of an 8 per cent solution, and continued with successive dilutions of 4, 2, 1, 0.5, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005, 0.002, 0.001 and 0.0005 per cent, as results warranted proceeding further. In the case of *Cacoecia*, only 2cc. of the spray solution were used: with *Agrotis*, spraying was commenced with 4 cc. of a 4 per cent concentration.

After being sprayed the larvae were returned to the most favorable conditions of feeding and were kept at 70°F. and 70 per cent R.H. for a given observation period before being counted for mortality. *Agrotis* larvae were returned to individual salve tins with fresh soil and wheat foliage and kept for 4 days. *Heliothis* larvae were transferred to flax stems (kept in water) within 2-quart sealers with screened tops and left for 4 days. *Cacoecia* larvae were transferred to fresh spruce shoots in ½-pint waxed cardboard (Sealright) containers with minutely perforated lids, and kept for 3 days.

Parallel control samples were tested by spraying *Agrotis* and *Heliothis* larvae with 4 cc. of the benzene-kerosene solvent alone. No mortality was observed with either species during the 4-day observation period. Parallel control sprays using 2 cc of solvent with *Cacoecia* larvae however showed an average mortality of 22 per cent for the 3-day observation period. The experimental figures were therefore corrected by Abbott's formula (1925) for this degree of control mortality.

RESULTS:

The percentage mortalities obtained with successive dilutions of the 15 compounds tested against the 3 species of insects are not reported here: However, the results obtained with the 4 compounds that proved to be most toxic for *Agrotis*, *Heliothis* and *Cacoecia* respectively are shown in Tables 1, 2 and 3. The percentage mortalities are related to the density of deposit in gamma per square centimetre. As was mentioned above, a deposit of 160 gamma/cm² would be given either by 4 cc. of a 4 per cent solution or by 2 cc. of an 8 per cent solution.

TABLE 1.

Mortality Data for the 4 most toxic Insecticides tested against Agrotis
(Control Mortality: Zero)

	% Mortality at Deposits in gamma/cm²						
INSECTICIDAL COMPOUND	160	80	40	20	10	5	2.5
Gammexane	100	100	100	100	80	40	20
DNOC	100	100	100	100	80	20	0
Pyrethrins	—	100	100	100	70	10	0
Chlordane	100	90	80	60	30	—	—

TABLE 2.

Mortality Data for the 4 most toxic Insecticides tested against Heliothis.
(Control Mortality: Zero)

	% Mortality at the following Deposits in gamma/cm²								
INSECTICIDAL COMPOUND	160	80	40	20	10	5	2.5	1.25	0.62	0.31
Pyrethrins	—	100	100	95	72	36	25	30	25	10
DDT	100	100	100	80	46	38	30	—	—	—
DNOC	100	100	100	80	70	2	—	—	—	—
Gammexane	100	92	59	38	30	20	—	—	—	—

TABLE 3.

Mortality Data for the 4 most toxic Insecticides tested against Cacoecia. (Corrected for Control Mortality of 22 per cent).

INSECTICIDAL COMPOUND	Per cent Mortalities at the following Deposits in gamma/cm²											
	40	20	10	4	2	1	0.4	0.2	0.1	0.04	0.02	0.01
Pyrethrins	100	98	98	98	100	100	100	100	72	39	32	26
DDT	100	100	98	94	85	64	64	49	42	17	—	—
Gammexane	98	100	94	64	63	39	36	—	—	—	—	—
DNOC	100	91	76	57	31	26	—	—	—	—	—	—

The percentage mortality figures were plotted on graph paper relating the logarithm of the deposit density to the mortality in probits (vide Bliss, 1935). From the linear relationships obtained for each compound, the median lethal concentration (or LD 50) and the LD 90 could be read off. The values for LD 50 and LD 90 obtained for all the compounds with the 3 species are listed in Table 4. Where the LD 90 or LD 50 was in excess of 400 gamma/cm², the symbol "Neg" is employed to indicate non-toxicity at that level. The symbol "—" indicates that the compound was not tested against the species concerned.

It will be noted that Pyrethrins, Gammexane and DNOC comprise 3 out of the 4 best compounds for all three species of lepidopterous larvae. The fourth compound is DDT, but this is replaced by Chlordane in the case of *Agrotis*.

TABLE 4

Approximate Median Lethal Deposits (LD 50) and LD 90 figures of 15 insecticidal compounds for certain Lepidopterous Larvae, expressed in gamma per square centimetre.

INSECTICIDAL COMPOUND	Cacoecia		Heliothis		Agrotis	
	LD 50	LD 90	LD 50	LD 90	LD 50	LD 90
DDT	0.3	2.7	7.0	80	80	115
Methoxy-DDT	—	—	—	—	75	250
Gammexane	1.9	6.7	23	80	5.5	12
Nicotine	42	160	400	Neg	Neg	Neg
Toxaphene	—	—	—	—	28	50
DNOC	4.0	19	16	38	7.5	12
DNOCHP	—	—	—	—	Neg	Neg
Lethane 60	Neg	Neg	Neg	Neg	Neg	Neg
Lethane 384	90	400	Neg	Neg	—	—
Thanite	110	Neg	Neg	Neg	—	—
Azobenzene	160	Neg	Neg	Neg	—	—
Chlordane	140	Neg	Neg	Neg	18	60
Hexaethyl tetraphosphate	—	—	—	—	105	200
Pyrethrins	0.05	0.1	4.0	14	8.2	13

Examination of Table 4 will show that these 4 insecticides are followed by 3 compounds of generally moderate toxicity, namely rotenone, chlordane and toxaphene. Occasional light to moderate toxicity was shown by nicotine, hexaethyl tetraphosphate, Lethane 384, and methoxy-DDT. Negligible toxicity when tested was shown by Thanite, Lethane 60, DNOCHP and azobenzene.

DISCUSSION:

It is noteworthy that, on the basis of weight of active compound in the spray, the Pyrethrins are the most generally toxic of all the compounds to these lepidopterous larvae. However it must be remembered that these figures are assessments of the direct contact toxicity: field use requires that an insecticide should possess a high residual toxicity, which pyrethrins do not show. This handicap resulted in inferior control of lepidopterous larvae on cabbage as compared with DDT (Huckett, 1946). The difficulty and expense of obtaining pyrethrin solutions of high concentration should also be pointed out.

For the spruce budworm (*Cacoecia fumiferana*) and the flax bollworm (*Heliothis ononis*), it is evident that the best insecticide of the series tested is DDT. In addition to the superior direct contact toxicity as shown in these tests, DDT can be relied upon to show high residual toxicity. However, it is remarkable that the pale western cutworm (*Agrotis orthogonia*) is able to withstand moderately low applications of DDT without showing any adverse symptoms, and that no less than 6 compounds were found to be more toxic than DDT to this species.

Gammexane, the gamma isomer of benzene hexachloride, ranks high among the most toxic compounds for all three of the insects tested, as indeed it does for a high proportion of all insect species. Due to the appreciable volatility of this compound, its toxicity to the respective species is probably influenced by the degree of ventilation afforded during the observation period after the application of the spray. Thus it is not surprising that the highest toxicity was shown to pale western cutworm larvae, since they were closed in air-tight salve tins. A recent paper by Bottger and Levin (1946) has reported the superiority of gammexane to DDT to lepidopterous larvae in tests performed in the laboratory. It is evident that the toxicity of gammexane to *Cacoecia* and *Heliothis* is insufficient for its being considered preferable to DDT for field use since deposits volatilize away readily. However, it shows some promise for use against soil-inhabiting insects such as *Agrotis*.

The high contact toxicity of DNOC (3,5-dinitro-ortho-cresol) to all three species is of more than passing interest. The advantages of this material are that it is cheap and can be relied upon to give rapid kill. However it is dangerous to use, since deposits of over 5 lbs/acre density are liable to burn foliage. Moreover its residual toxicity is low, although Carlson and Yothers (1946) have recently reported it to show considerable residual effect to codling moth larvae.

It is interesting that Chlordane, which has shown superior toxicity to that of DDT to most insect species (Kearns, Ingle and Metcalf, 1945) was entirely without effect on *Heliothis* and of very slight toxicity to *Cacoecia*. Only in the case of *Agrotis* does it show sufficient toxicity to warrant its investigation in the field. Toxaphene, reported as highly effective against codling moth by Stearns et al. (1947), proved to be even less toxic than chlordane to the pale western cutworm.

Of the seven remaining insecticides assessed, none showed a high degree of toxicity, although not all the compounds were tested against all three species. The thiocyanates (Lethanes and Thanite) were generally ineffective. However nicotine, methoxy-DDT and hexaethyl tetraphosphate showed a considerable degree of toxicity in some cases. It is considered worth while investigating some of these less promising compounds, since they are more likely to yield a good selective insecticide than the well-known compounds of high toxicity to a wider range of species.

SUMMARY:

Fifteen organic insecticidal compounds were tested for their direct contact toxicity to larvae of *Agrotis orthogonia, Heliothis ononis* and *Cacoecia fumiferana* (Lepidoptera). The compounds were dissolved in benzene-kerosene mixture and applied at graded concentrations in a spray tower.

The pyrethrins, gammexane (the gamma isomer of benzene hexachloride) and DNOC (3,5-dinitro-o-cresol) were among the 4 most toxic compounds to all 3 species of lepidopterous larvae.

DDT was highly toxic to *Heliothis* and *Cacoecia* larvae, but only slightly toxic to *Agrotis* larvae. Chlordane was moderately toxic to *Agrotis* larvae, but exhibited very slight effect on the other two species.

Rotenone and Toxaphene were moderately toxic to the species tested. Nicotine, Methoxy-DDT, Lethane 384 and hexaethyl tetraphosphate showed occasional slight to moderate toxicity. Negligible toxicity when tested was shown by Thanite, Lethane 60, DNOCHP and azobenzene.

ACKNOWLEDGEMENTS:

A special acknowledgement is gratefully made to Mr. L. A. Jacobson, Dominion Entomological Laboratory, Lethbridge, Alberta, who inaugurated the testing program with pale western cutworm, and to his assistants Messrs. R. A. Forster and P. E. Blakeley. Assistance in the flax bollworm programme was provided by Mr. W. R. Allen, Dominion Entomological Laboratory, Brandon, Man. and Mr. D. F. Hardwick, Dominion Entomological Laboratory, Saskatoon, Sask.

The samples of purified DDT and DNOC were prepared by Dr. D. B. W. Robinson, Experimental Station, Suffield. The samples of purified chlordane, DNOCHP and rotenone were prepared by Prof. G. F. Wright, University of Toronto.

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THE EFFECTS OF A MISCIBLE OIL, A DI-NITROL COMPOUND, AND D.D.T. EMULSION UPON THE EGG MASSES OF THE EASTERN TENT CATERPILLAR *MALACOSOMA AMERICANA* L.

BY W. I. JOHANSSON, LOIS ROSENE, AND C. N. WARNER

In the course of laboratory tests with insecticides, some interesting data were obtained relative to the effect of certain materials upon the overwintering egg masses of the Eastern tent caterpillar. The data appear to be of sufficient interest to warrant further study and are presented here with that purpose in mind.

A number of egg masses was collected. These were brought into the laboratory, were examined and sorted into lots roughly comparable in numbers. The twigs to be sprayed were segregated. Solutions of the following insecticides were then prepared.

1. A miscible oil, having 97% oil, was diluted to a concentration of 4% by mixing 154 ml of the oil with one gallon of water.

2. A Di-nitro compound, diluted 1 to 50 giving a 2% solution, and obtained by mixing 76 ml with one gallon of water.

3. A 25% D. D. T. emulsion was diluted 2.4 ml to one gallon of water, giving a 1-1600 dilution.

4. A 25% D.D.T. emulsion was diluted 4.8 ml to one gallon of water, giving a 1-800 dilution.

PROCEDURE:

With the thought in mind that the D.D.T. solutions would be most likely to leave a residue in the equipment used, the miscible oil and D.N solutions were prepared and applied first. The insecticides were measured in a 100 ml graduated cylinder and mixed with the water in a gallon measure. All solutions were mixed thoroughly before being applied. Applications were made by means of a small hand sprayer. Thorough coverage was obtained and the twigs with sprayed clusters were then placed in separate containers. The equipment was washed carefully between each insecticide used. The treated clusters were placed in jars containing a small amount of water.

RESULTS:

After 90 hours, the egg masses were observed and the results tabulated. The D.D.T. 1-800 and 1-1600 solutions both reduced the emergence of the larvae to a considerable degree. The D.D.T. 1-800 cut emergence down to 29 larvae per cluster, but there were 22 which had dropped into the water that were alive. The D.D.T. 1-1600 test had 100% kill with an average of 109 emergence per cluster.

The miscible oil test had only 6 dead out of a total of 311 larvae emerged from 2 clusters. There were 305 crawling larvae. The Di-Nitro test showed 100% kill with an average of 86 emerging from each of 2 clusters. The check showed 439 alive at the end of 90 hours, with no dead and an average of 146 emerging from each of three clusters.

The 22 live larvae in the water of the 1-800 D.D.T. seems to conflict with the 100% kill of the 1-1600 D.D.T. However, emergence was cut almost 2/3 with the 1-800 solution. The Di-nitro shows an effective kill of 100% also, but an emergence of 86 per cluster. The miscible oil proved ineffective and probably further tests with D.D.T. 1-800, and 1-1600 and Di-nitro will clarify the apparently conflicting results.

While these tests are admittedly preliminary, the fact is evident that the treatments reduced the emergence and that also the larvae died, in general, soon after emergence. If tent caterpillars can be controlled by an application during the egg stages, the destruction of foliage and the unsightly nests can be avoided.

In conclusion, under laboratory conditions, tests indicate the possibility of control of the Eastern tent caterpillar through the application of either a D.D.T. emulsion or a Di-nitro compound being tested experimentally.

DATA AFTER 90 HOURS

Data	D.D.T. 1—800	D.D.T. 1—1600	Miscible Oil	D N Compound	Check
No. egg clusters	3	2	2	2	3
No. larvae emerged	87	218	311	172	439
Emergence per cluster	29	109	155	86	146
Larvae alive at end of 90 hours	22	0	305	0	439

NOTES ON THE EFFECTS OF PHYSICAL FACTORS ON THE SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA* (CLEM.)[1]

BY W. G. WELLINGTON AND W. R. HENSON,

Forest Insects Laboratory, Sault Ste. Marie, Ontario

The meteorological program of the Sault Ste. Marie Forest Insect Laboratory was inaugurated during 1946, with the establishment of stations at Sault Ste. Marie and Black Sturgeon Lake, for the study of the spruce budworm, *Choristoneura fumiferana* (Clem.) (*vide* Freeman, 1947) as its first subject. During 1946 and 1947, joint field and laboratory studies have been concerned primarily with the effects of evaporation, temperature, light and air currents upon the behaviour and activity of the insect. Recently, the work has been extended to include studies of the stages which can be dispersed by air currents and studies of certain aspects of the microclimates of the habitat.

Some of the results obtained during the past two seasons are of general interest, and discussions of these, together with descriptions of special apparatus and techniques, will appear elsewhere. Other results, which are of interest to those directly concerned with the spruce budworm, are reported here as specific examples of the bearing of meteorological factors on the life of the insect. This method of presentation presupposes familiarity with the life-cycle of the insect (cf. Swaine *et al.*, 1924; Graham, 1935; Atwood, 1944).

The first behaviour of the spruce budworm recognizable as a direct response to a physical factor occurs immediately after the first stage larvae emerge from the eggs in mid-summer. On emergence, larvae react postively to light, which leads them to the tip of the needle to which the eggs are attached. At the needle-tip, crowding causes many of the group to drop on silken threads.

At such times, one of two things may happen to a larva suspended on silk. It may drop down far enough to land on another twig beneath it, or, under the proper weather conditions, it may be caught in vertical air currents of low velocity and be borne above the level of the trees. Either occurrence tends to disperse the members from an egg mass over a wider area and, if larvae reach other twigs, they again react positively to light and move towards the periphery of a tree.

If a moving larva is shielded from direct insolation by the presence of a cloud cover, photopositive behaviour persists until the larva contacts debris such as staminate flower scars or lichen, whereupon the photic stimulus is replaced by a tactile stimulus and the larva settles in the debris. On the other hand, if the sky is clear, the larva, on nearing the periphery, may be warmed above its reversal temperature (approximately 84°F.) by radiant heat so that it becomes temporarily photonegative and is driven away from the region exposed to direct insolation to a shaded portion of the tree. In either case, contact with debris results in the construction of a hibernaculum, provided the air is dry enough to permit silk spinning. Nevertheless, from the standpoint of future survival, it is interesting to note that larvae emerging on overcast days, when they cannot be driven by radiant heat to more sheltered portions of the tree possibly might spin in situations where they would be endangered by dessication during the subsequent hot, dry weather.

Larvae in hibernacula moult and overwinter in the second instar. The effects of weather conditions upon overwintering larvae is a subject

[1]Contribution No. 2516, Division of Entomology, Science Service, Department of Agriculture, OTTAWA, Ontario.

for future research, but, for the purposes of this report, survival and successful emergence in the spring may be assumed. Newly emerged second stage larva are strongly photopositive, and remain so throughout the instar at the temperature prevalent in the field. It is this photic response, rather than the geonegative one suggested by Swaine *et al.* (op. cit.), which tends to draw the larvae towards the periphery, the region of most suitable food.

During these movements from hibernacula to buds or needles, larvae of this instar also are susceptible to dispersal by air currents. Air-borne dispersal in this stage appears to differ from that in the previous stage, in that, while the first instar is active during a season characterized by strongly convective weather, the second instar is active during a season which, in the north country, is characterized by turbulent weather. Thus, although both stages disperse with the aid of silken strands, which implies long-range dispersal, the first instar is subject to the effects of broad areas of strongly marked down-drafts which tend to nullify the added efficiency of the silk. On the other hand, second stage larvae drifting in turbulent air flow theoretically are susceptible to wider-range dispersal, and there is some field evidence of this.

During the second stage, which is the first in which feeding occurs, low air temperatures are common in the field. There are indications that the larvae do not feed below a temperature of about 50°F. if the sky is overcast. On the other hand, under clear or broken skies, direct insolation warms the foliage enclosing the larvae so that they are able to feed at air temperatures below 50°F.

These young larvae feed inside a needle or a tightly packed bud, where moisture conditions approach saturation. This is an apparent anomaly, since laboratory observations have shown that saturated air depresses the locomoted activity of all instars, and field observations have shown that later stages are sluggish and do not feed during periods of rain of light to moderate intensity. Thus, since the young larvae do feed while enclosed in plant tissues, whereas later stages in expanding shoots normally are sluggish in saturated air, either some factor, such as increased oxygen percentage, must be present in needles and buds to counteract the observed effects of low evaporation, or else mandibular movements of young larvae are not markedly affected by a low rate of evaporation.

Light reactions once more become progressively important during the last three instars. These larvae, when fully fed respond photopositively, just as the first three instars do. In addition, if sufficiently heated (approximately 100°F. in the case of the last instar) they behave like the earlier instars by reacting photonegatively to all types of light. However, unlike the earlier instars, their responses to a *discrete* source of light are reversed by some effects of progressive starvation which do not affect photopositive behaviour to light intensity as such.

Photic reversal brought about by progressive starvation should occur only in old, heavy infestations on days when the disc of the sun is visible, but reversal brought about by a high body temperature can occur in any type of infestation wherever larvae are exposed to direct summer sunlight. Either type of reversal will produce dropping to lower parts of a tree, or to the forest floor, but high temperature reversal also will produce movements towards the trunk of the tree with subsequent returns to the exposed periphery when this is returned to shadow. To these movements in response to light also must be added another type of dropping which occurs in the last instar in response to vibration by strong winds or in response to sudden flooding of the tunnels by intense thundershowers. Both vertical and horizontal movements raise problems in the development of an adequate samp-

ling technique, if this is based on the positions of larvae, rather than damage, and failure to allow for the movements may give a distorted picture of population density.

With reference to the adults, it is of interest to note that fully gravid females cannot fly, but become capable of active flight after dropping one or two masses of eggs. This suggests that, other things being equal, females will deposit their first few egg masses upon the trees on which they emerge. Both sexes are susceptible to dispersal by air currents, but observations are still in progress, and few definite statements concerning the relation of weather conditions to mass flights may be made at this time.

OBITUARY, GEORGE SHIRLEY BROOKS.

The death of George Shirley Brooks on Monday, November 3rd, 1947 has removed yet another of those hobbyists who have done so much to advance our entomological knowledge.

Born in Suffolk, England, in 1872, even in his youth Shirley Brooks showed that intense interest in Nature that was to be a controlling factor in the use of his leisure hours.

Coming to Canada in 1911 he spent a few months farming and then entered the service of the Canadian National Railways in Transcona, Manitoba. Quiet and retiring, he continued his studies of the local butterflies, until the formation of the Natural History Society of Manitoba—in which he took a prominent part—compelled him to assume a position of leadership.

Always prominent at meetings of the Society, he was never too busy to help those who sought help or advice, and at his summer home at Victoria Beach, Manitoba, the door was always open to anyone interested in entomology or indeed in any branch of Natural History.

Following his superannuation in 1937, he divided his time among the Manitoba Museum, expeditions to such places as Churchill and his own collections.

For a time he specialized in Diptera but finding that order in such confusion returned to his first love, butterflies. His keen collecting added a number of species to the Manitoba list and several new ones to Science.

His special interest in the Manitoba Museum was shown by his gift to that institution of an almost complete collection of Manitba butterflies. in beautiful condition. His loss to the M. N. H. S. is a very severe blow as he was perhaps its hardest working member, serving as President, and as Secretary for many years.

His loss to the M.N.H.S. is a very severe blow as he was perhaps its hardest working member, serving as President, and as Secretary for many years.

Shirley Brooks was first and last a collector. He loved being out in the sunshine, net in hand, among the trees and flowers searching for perfect specimens which he mounted with consummate artistry. He was not interested in describing new species and it was only with difficulty that he could be persuaded to prepare his list of the Butterflies of Manitoba published in the Canadian Entomologist, LXXIV. P31 et seq. February, 1942.

AN UNUSUAL NESTING SITE FOR THE ANT *LASIUS FLAVUS NEARCTICUS* WHEELER

On July 30, 1947, what appeared to be the nuptial flight of the above species occurred in the home of a resident of Windsor, Ontario. Hundreds of males and females appeared suddenly from the base of the toilet in the bathroom on the ground floor of the cottage and flew to the open screened window. Dr. William S. Creighton, who identified the species, has remarked

that the choice of such a nesting site was certainly unusual for an ant which normally nests outdoors. The fact that a similar appearance was observed by the residents, two years previously, in the same location and on almost the same day, is of additional interest. This inquiry constitutes a rare household record among the many insect problems which are constantly being received at our plant inspection office in this region.

S. D. Hicks,
Plant Inspection Office, Windsor, Ontario.

BRACHYRHINUS RAUCUS (FAB.), AN EUROPEAN WEEVIL NEW TO NORTH AMERICA

The following records of *Brachyrhinus raucus* (Fab.) suggest that this European species previously unreported from America, is established in Ontario. On May 27, 1936, I found a single specimen crawling on sandy soil in the Fonthill Nurseries, Fonthill (near Niagara Falls), Ontario. The specimen was determined by Mr. W. J. Brown and is deposited in the Canadian National Collection. This collection contains also, Mr. Brown informs me, a specimen taken in Beechwood Cemetery, Ottawa, Ontario, on May 17, 1943, by Mr. A. R. Brooks and another taken at Toronto, Ontario, on June 16, 1937. The latter was taken with two others by Mr. H. S. Parish; these were identified by Mr. L. L. Buchanan and are in the collections of the United States National Museum and of Mr. P. C. Ting.

S. D. Hicks,
Plant Inspection Office, Windsor, Ontario.

BOOK REVIEWS

"The Birds of America' by John James Audubon, with introductory and descriptive text by William Vogt. Pages I/X, 435 colour plates. MacMillan and Co., New York and Toronto. 1946. 5th printing. $7.95

Naturalist and bird lovers will be glad to learn that Audubon's "Birds of America" is again available. As this is the fifth reprinting it is questionable if it will be printed again from the original plates, and therefore again be available at the present reasonable price.

"Handbook of the Trees of the Northern United States and Canada" by Romeyn B. Hough. Pages I-X, 1-470; 495 photographs, 190 distribution maps; MacMillan and Co., New York and Toronto, 1947, $5.50.

The author, Romeyn B. Hough, is the son of Dr. Franklin B. Hough, the pioneer commissioner of Forestry in the United States. The "Handbook of Trees of Northern United States and Canada (East of the Rockies)" is the result of his natural love of trees, supplemented by a thorough botanical training and years of field work.

In this volume the author has succeeded in preparing a handbook which will enable almost everyone to identify the 200 odd species of native and naturalized trees of the northern states and Canada, described and figured in the text. For convenience the text matter and illusrations pertaining to each species are arranged on two pages, opposite one another. The salient features of each species, such as general form, average size, leaf characteristics, habitat, and nature of the wood and its uses are given. The species are illustrated by photographs of branchlets with mature leaves, fruit, branchlets in winter, and the trunk (usually of a medium sized tree) to show the nature of the bark. The photographs showing branchlets, leaves, and fruit, have a background marked in one inch squares, while a measure (usually one foot long) is shown placed across the trunks of the trees, to indicate size. In the description of many species an outline map shaded to indicate distribution, and a photo of wood structure, are included.

The description of species is supplemented by a short key to the families of trees based mainly upon flowers, and a synopsis of the families and genera represented in the text, with analytical keys to the species. There

is also a useful six-page glossary, and an index of accepted botanical names, synonyms, and common names.

This book with its many excellent illustrations and interesting specific descriptions should be of value to everyone who works with trees, whether forester, botanist, entomologist, lumberman, amateur or professional.

"DDT and the Insect Problem" by James C. Leary, Wm. I. Fishbein and Lawrece C. Salter. 176 pages, 9 figures. MacMillan and Co., New York and Toronto. 1947. $2.50.

This small volume by J. C. Leary, president of the National Association of Science Writers, W. I. Fishbein, Chicago Health Department, and L. C. Salter of Salter & Associates (former science editor of the Detroit Free Press) written in non-technical language, is a summary designed to furnish essential information to the 'ordinary' users of DDT. No attempt has been made to present a complete summary of the literature on DDT for the use of research workers, or professional entomologists.

The introductory chapter outlines in a general way some of the advantages and disadvantages of DDT, its effect on beneficial insects, bees, and the balance of nature. Mention is made of 666 TDE, and DD. Chapter II, "Insects and Insecticides", briefly reviews the damage caused by insects, their numbers as compared with other animals, value of estimated damage, and the value of beneficial forms. The chemistry and pharmacology of DDT are discussed in Chapter III. The chemistry is reduced to a very simplified description, while the pharmacology and toxicology are reviewed at moderate length. The remaining chapters IV to VIII (pp. 50-164) deal with:—the use of DDT, in solutions, emulsions, water suspensions, dusts aerosols war uses of DDT; man's health and comfort, including brief dicussions on insect borne diseases, household insects, domestic animals; agriculture; forest, shade and fruit tree insects.

This volume, with its clear non-technical instructions for the efficient and safe use of DDT in crop and animal protection and for the destruction of household and garden pests, should prove a handy reference to the general users of DDT, who do not wish to be concerned with technical details.

"Principles of Forest Entomology" by Samuel Alexander Graham. McGraw-Hill Book Co. Inc., New York and London (Embassy Book Co. Ltd., Toronto). 2nd impression, 2nd edition $4.95.

Students of Forestry and Forest Entomology in particular should be glad to learn that Graham's "Principles of Forest Entomology" is again available. Unlike most books on the subject, the text is in large part a clear and concise statement of the complicated interrelationships of forest life, and as such should serve as a sound basis for those interested in the protection of our forests.

R. H. Ozburn

REPORT OF THE ACTIVITIES OF THE MONTREAL BRANCH OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

This is the 74th Annual Report of the Montreal Branch and we believe concludes a successful year.

Eight regular meetings were held during the 1946-1947 year with a total attendance of 122 or an average of 15 for each meeting. We met six times in the Lyman Room, McGill University, once in the Entomological Laboratory of the University of Montreal and once in the Entomological Laboratory at Macdonald College.

We were fortunate in having a visitor, Mr. A. G. Dustan, of the Entomological Branch, Dept. of Agriculture, Ottawa visit us on March the 14th. Mr. Dustan gave us a very interesting talk on his experiences on a 5000 mile trip by air along the Mackenzie River, illustrated with Kodachrome slides. A good attendance was recorded on this occasion.

We also had a successful meeting at Macdonald College with 27 members and guests present at this event.

During the year four new members were elected to our Society.

Our Annual Field Day was held on May 24th when a small group visited Laval des Rapides.

The following 19 papers and talks were given during the year under review:—

1.	Presidential Address—A Review of two books—Russell's—The Directiveness of Organic Activities, and Lillie's—General Biology and Philosphy of Organism"	Geo. A. Moore
2.	Season's Activities	H. V. Green
3.	Report on the Season's Collecting	Geo. A. Moore
4.	Report on Experiments Undertaken During the Year	H. A. U. Monro
5.	Report on Annual Meeting at Guelph	Rev. O. Fournier
6.	Points of Distinction Between Papilio rutulus and the Forms of Papilio glaucus	H. V. Green
7.	The Phasmidae or Walking Stick Insects	Geo. A. Moore
8.	A New Type of Killing Bottle	H. A. U. Monro
9.	Methode de Nenombrement d'Hylurgopinus rufipes Eich. dans des Arbres Atteints de la Maladie Hollandaise de l'Orme	Bro. A. Robert
10.	The Biology of Mantispa brunnea Say	C. Chagnon
11.	The Mecoptera or Scorpion Flies	Geo. A. Moore
12.	A Review of the newly published Check List of British Insects	Geo. A. Moore
13.	Nature subjects illustrated with Kodachrome slides	Dr. G. H. Fisk
14.	An outline of the First Post-War Conference of the Division of Plant Protection	H. A. U. Monro
15.	A Review of the book "Insect Dietary"	Geo. A. Moore
16.	My work on the Dutch Elm Disease	N. P. Beaudoin
17.	Impressions, Entomological and otherwise, gained along the Mackenzie River	A. G. Dustan
18.	Studies on the mysterious tumour forming virus disease which has reduced the European Spruce Sawfly from a major pest to one of little significance	F. T. Bird
19.	Arousing the study interest in Entomology	Dr. F. O. Morrison

Officers elected for the year 1947-1948

President	Geo. A. Moore
Vice President	Rev. Father O. Fournier
Secretary-Treasurer	A. C. Sheppard
Council	Messrs. G. Chagnon, E. Munroe, H. A. U. Monro, E. R. Bellemare, J. B. Maltais and Dr. G. H. Fisk

A PRELIMINARY TEST OF DDT AND BENZENE HEXACHLORIDE FOR THE CONTROL OF WIREWORMS IN A SASKATCHEWAN POTATO FIELD[1]

BY A. P. ARNASON[2], W. B. FOX[3], AND R. GLEN[4]
Dominion Entomological Laboratory, Saskatoon, Saskatchewan

An inexpensive, simple, chemical control of wireworms in land to be used for vegetable production has long been sought in the Prairie Provinces. Existing methods of control (3, 4, 5, 6) are not wholly satisfactory for row crops. The cultural measures commonly advocated (6) will reduce wireworm infestations sufficiently that cereal crops can be grown without serious damage, but they are not usually sufficiently effective that potatoes or other row crops can be produced successfully. Crude naphthalene is the most satisfactory of the chemical methods recommended (3, 4, 5) but it is too costly for material, is difficult to handle and apply, and is effective only under certain conditions of soil, moisture and temperature. As a result, commercial potato production on the prairies has been restricted largely to districts and fields where wireworms are virtually absent.

The investigation reported in this paper was undertaken in 1945 and 1946 to determine the value of DDT and benzene hexachloride in the control of wireworms. It was conducted at Saskatoon, Saskatchewan, in a garden of silty loam soil where wireworms, especially *Ctenicera aeripennis destructor* (Brown)[5], had been a serious pest of potatoes for several years. The chemicals were tested through direct application to the soil and as seedpiece treatments. This preliminary test constitutes the first invesigation in Canada, if not also in North America, involving the use of benzene hexachloride for the control of wireworms.

SOIL TREATMENTS

Four plots, each nine feet by thirty-three feet, and a fifth half-length plot were used in this test. These were arranged side by side in a single series and treated in the following order: DDT at 100 pounds per acre, check, DDT at 20 pounds per acre, benzene hexachloride, check (half plot). No estimate of wireworm abundance was made prior to application of the chemicals since previous observation had established the fact that a sufficiently severe and uniform infestation existed to meet the requirements of a preliminary test.

The DDT (Geigy Company Technical DDT) was applied on April 23, 1945, at a rate of 100 pounds per acre in one plot and 20 pounds per acre in the other. To facilitate uniform distribution within each plot, the chemical was mixed with a small quantity of soil and spread with a trowel. The entire garden was then ploughed seven to eight inches deep, and harrowed.

The benzene hexachloride (Imperial Chemical Industries PC982Y, reported to contain 20 per cent crude benzene hexachloride in gypsum, which equals 2.5 per cent gamma isomer) was applied on May 25, 1945, at a rate of 25 pounds PC982Y per acre. This is the equivalent of 5 pounds crude

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[5]The prairie grain wireworm usually referred to under the name *Ludius aeripennis destructor* (Brown) in most economic publications of the past 15 or 20 years. Other scientific names applied to this species include: *Ludius tinctus* (Lec.), *Ludius aereipennis* (Kby.), and *Corymbites aereipennis* (Kby.)

material or approximately 0.63 pounds gamma isomer per acre. The method of application was the same as that described for DDT, but talc, instead of soil, was used as a diluent and as a visual aid in securing uniform distribution. Since the garden had already been ploughed, the chemical was spaded in to a depth of seven to eight inches. Hereafter, benzene hexachloride is referred to in this paper as "BHC".

All plots were planted on May 25, 1945, using No. 1 grade Early Ohio potatoes. The seed pieces were not treated. Three rows were planted in each plot, the rows being three feet apart with the outside rows one and one-half feet inside the plot margins. Hills were spaced sixteen inches apart in the row. No cultivation, except that required for weed control, was given during the season. Fertilizers were not used and the plots received only the natural rainfall. Insect pests, other than wireworms, were unimportant.

The potatoes were dug during the first week of October. At that time records were made of the wireworm population, damage, and yield. All data were taken from the middle row in each plot. Wireworm abundance was determined by examining ten 'square foot' sample units — each centered on a hill — in each plot, with the exception of the half-length check plot in which only five sample units were taken. Each sample unit measured 12 inches by 13 1/16 inches, being equivalent to 1/40,000 acre, and was taken to a depth of 10 inches. No sampling was done, at this time, in the spaces between rows. The yield and damage records taken in each plot included: (1) the total number and weight of tubers of "commercial" size (two inches or more in diameter) and of "sub-commercial" size; and (2) the number of wireworm tunnels in each tuber.

In June, 1946, another wireworm census was taken. However, at this time sampling was done both in the former rows and in the inter-row spaces for it was known that the wireworms, which were concentrated in the potato hills the previous autumn, had dispersed to a considerable extent. For this reason, the population figures for October and June are not directly comparable.

The wireworms taken in sampling were all *Ctenicera aeripennis destructor* (Brown) with the exception of one larval *Hypolithus nocturnus* Esch. and one adult *Aeolus mellillus mellillus* (Say). All living larvae were kept under observation in individual rearing tins for several weeks after sampling.

Effects of Soil Treatment on Wireworm Infestation

An examination of Table 1 reveals that by October, 1945, the chemical treatments had reduced the wireworm infestation in the potato rows as follows: BHC, 89 per cent; 100 pounds DDT per acre, 63 per cent; 20 pounds DDT per acre, 23 per cent. That the chemicals were still affecting the wireworms in October was evidenced by the fact that of the ten living larvae taken from the BHC-treated plot seven were sluggish and all died within two weeks, and two larvae out of twenty-eight taken in the plot treated with DDT at the 100 pound rate also died. No post-sampling mortality occurred among larvae taken from the other plots. It was the possibility that the BHC treatment might ultimately result in complete control that prompted taking a further census the following June, just prior to the period when the new brood of larvae normally appears. The reductions in wireworm abundance recorded at that time were: BHC, 93 per cent; 100 pounds DDT per acre, 76 per cent; 20 pounds DDT per acre, 23 per cent. These figures indicate that relatively little wireworm mortality actually occurred after October, 1945.

Table 1: Wireworm infestations per 1/40,000 acre in experimental plots treated in the spring of 1945

Treatment	Infestation October, 1945 In potato rows Larvae	Adults	Total	June, 1946 In between rows[1]	Av.[2]
BHC	1.0	0.0	1.0	0.4	0.2	0.3
DDT (100 lb.)	2.8	0.5	3.3	2.2	0.2	0.9
DDT (20 lb.)	6.3	0.6	6.9	6.0	1.5	3.0
Check	8.1	0.6	8.7	4.6	3.6	3.9
Check (half plot)[1]	8.4	0.8	9.2	—	—	—
Av. of checks	8.2	0.7	8.9	—	—	—

The elaterid populations that remained one year after treatment are shown in the last column of Table 1. In the plot treated with BHC, the infestation of 0.3 wireworms per 1/40,000 acre is not likely to cause more than light damage even to crops that are highly susceptible to wireworm attack. However, in the plot treated at the rate of 100 pounds DDT per acre enough wireworms (0.9 per 'square foot') are still present to cause considerable damage to potatoes. Furthermore, this rate of DDT is too costly to be practicable. The infestation of 3.0 wireworms per square foot that remained in the plot treated at the rate of 20 pounds DDT per acre would commonly result in extremely severe damage to potatoes.

No adult elaterids were recovered in the autumn in the BHC-treated plot. Adults were taken at that time in all other plots and were as numerous where DDT was used as in the checks. These results suggest that re-establishment of economic infestations would be delayed longer in fields treated with BHC than in fields treated with chemicals that do not prevent surviving mature larvae from transforming to adults.

Effect of soil treatments on damage

The data in Table 2 show that damage to the potato tubers was roughly proportional to the population of wireworms in the rows at digging time. No treatment prevented damage so completely that the crop could be graded as "Canada No. 1" table stock.

Table 2: Yield of potatoes and damage by wireworms to tubers grown in soil treated in the spring with BHC and DDT

Treatment	Total Tubers	Av. Wt per hill (ounces)	Percentage of tubers with the following no. of tunnels per tuber 0	1	2-4	5-9	10 (or more)	Av. no. tunnels per tuber
			ALL TUBERS					
BHC	152	21.9	85	9	6	0	0	0.2
DDT (100 lb.)	145	20.2	37	27	28	7	1	1.5
DDT (20 lb.)	127	22.7	23	20	36	17	4	2.8
Check	135	21.1	27	19	29	18	7	2.9
Check (half plot)	144	26.3	18	19	34	22	7	3.5
Checks combined	279	23.6	22	19	32	20	7	3.2
			TUBERS 2 INCHES OR MORE IN DIAMETER					
BHC	81	17.7	76	15	9	0	0	0.3
DDT (100 lb.)	94	18.2	32	23	33	11	1	1.9
DDT (20 lb.)	74	19.5	15	16	36	26	7	3.8
Check	78	18.7	13	15	32	28	12	4.1
Check (half plot)	103	24.4	11	19	34	27	9	4.2
Checks combined	181	21.5	11	18	33	28	10	4.2
			TUBERS LESS THAN 2 INCHES IN DIAMETER					
BHC	71	4.2	94	3	3	0	0	0.1
DDT (100 lb.)	51	2.0	47	33	18	2	0	0.9
DDT (20 lb.)	53	3.2	36	26	32	6	0	1.5
Check	57	2.3	47	22	25	6	0	1.2
Check (half plot)	41	2.5	37	17	34	10	2	1.9
Checks combined	98	2.4	41	21	30	7	1	1.5

[1]Based upon only 5 sample units.

[2]A weighted average in which twice as much weight is given to results from "between rows" sampling as to "in rows", the sample unit being one foot wide and the rows three feet apart.

In the check plots, damage to the new tubers was extremely heavy; 78 per cent of all tubers were attacked by wireworms, 59 per cent having two or more tunnels per tuber and the over-all average being 3.2 tunnels per tuber. The injury was most severe to tubers of commercial size, 89 per cent being attacked, with an average of 4.2 tunnels per tuber.

The DDT treatments failed to give satisfactory protection. The plot treated at the rate of 20 pounds per acre suffered almost as much injury as the checks. The application of 100 pounds per acre greatly reduced the incidence of wireworm attack, but even so only 32 per cent of the tubers of marketable size were free of wireworm tunnels.

By comparison, BHC gave very satisfactory results: 85 per cent of all tubers and 76 per cent of those of commercial size were undamaged, only 6 per cent had two or more tunnels per tuber, and the over-all average was only 0.2 tunnels per tuber. No tubers had more than four tunnels, consequently those that were damaged were less objectionable for table use than were potatoes from the other plots where more than five tunnels per tuber was common.

It appears likely that even greater tuber protection would have been secured had the BHC been applied at the same time as the DDT—late in April—since that would have increased by a month the period between treatment and tuber formation. The data reveal that in the BHC-treated plot 24 per cent of the early tubers and 6 per cent of the late tubers were attacked by wireworms, a ratio of 4:1. In the checks, the corresponding figures are 89 per cent and 59 per cent, a ratio of 3:2. It is evident, therefore, that the rate of wireworm feeding during the period of tuber formation declined much more rapidly in the BHC plot. This suggests that considerable wireworm mortality occurred after tubers began to form.

Dunn, Henderson, and Stapley (2) also found that a lengthy period is required before the full effect of BHC treatment is realized. Therefore, in order to secure the maximum reduction in damage to the tubers BHC should be applied to the soil as far in advance of planting as possible.

Effect of Soil Treatment on Flavour

The DDT applications did not impart any objectionable flavour to the new tubers. However, the potatoes harvested from the plot treated with BHC had the characteristic taint of the crude material. Even after being washed, peeled, and boiled this disagreeable odor was detected, in potatoes taken from storage, by all four individuals who participated in the test. Chemical analysis of tubers from treated plots—secured through the courtesy of the Division of Chemistry, Ottawa—failed to reveal the presence of either DDT or BHC.

Results from the other tests in 1946 and 1947 at Saskatoon and at Lethbridge, Alberta[6], fully confirm the fact that crude BHC applied at .63 pounds gamma isomer per acre at planting time imparts the typical BHC flavour to the potato crop. Potatoes grown in treated plots at Lethbridge in 1946, under both irrigated and dry land conditions, were contaminated by the characteristic flavour of crude BHC. Ten out of eleven people detected the taint in cooked samples from the irrigated plot and all detected an even stronger taint in the potatoes from the dry land plot. Potatoes

[6]The assistance of G. F. Manson, Officer-in-charge of the Dominion Entomological Laboratory, Lethbridge, for providing land, applying the treatments and for care of the plots at Lethbridge, is gratefully acknowledged.

grown in 1947 on the irrigated plots treated with BHC in 1946 also had some taint but the results of flavour tests were variable: one person might detect the flavour in one test piece, but not in another and ten of the seventeen persons participating detected no objectionable flavour. Potatoes grown at Saskatoon in 1947 on plots treated with BHC at planting were also distinctly tainted, but others from a plot treated with 0.5 pound per acre of purified BHC, containing 90% gamma isomer, were only slightly tainted as only four out of seventeen people participating in the test detected any off-flavour. The others considered the flavour normal.

Other Effects of Soil Treatments

No particular effect on growth or on potato yield can be attributed to the soil treatments. It might also be noted that no deleterious effect was observed on the growth, yield, or flavour of corn and beans grown on these plots in 1946, one year after the chemicals were applied. Potatoes from the BHC-treated plot grew and produced normally when used as "seed" in 1946.

SEED-PIECE TREATMENTS

Tests were made to determine the effect of the application of BHC and DDT to seed tubers upon the incidence of wireworm attack to the new crop. A row of thirty hills was used for each treatment and a check row of untreated pieces was planted between them. Geigy Company Gesarol AK20 (20 per cent DDT in pyrophyllite) was used for the DDT treatment, and Imperial Chemical Industries PC982Y (20 per cent crude benzene hexachloride in gypsum) was the BHC formulation used. In each instance a small quantity of the chemical was placed in a paper bag along with the seed pieces to be treated and shaken until all surfaces were well covered with the dust. All seed pieces were planted on May 25, 1945, immediately after treatment. No further examination of seed pieces was made except of those that failed to produce plants. The crop was harvested in mid-October and yield and damage records were taken. Although no counts of wireworms were made in this test, healthy larvae were noted in all rows at digging time.

Effect of Seed-piece Treatment on Plant Development

Growth and development of plants from the untreated and the DDT-treated seed pieces appeared to be normal in every respect. However, the thirty BHC-treated pieces produced only seven plants. These emerged between July 21 and July 28, some five to six weeks after plants had appeared in the other two rows. After emergence, the seven plants seemed to grow normally, but were so late that only a few small tubers were produced. Seed pieces that failed to produce plants were examined in late July and again in October and were found to be almost as sound as when planted, with little or no evidence of bud development.

Effect of Seed-piece Treatment on Rate of Damage

Wireworms did not bore into the BHC-treated seed pieces that failed to develop. Other seed pieces were not examined for incidence of wireworm attack.

As revealed in Table 3, neither the DDT nor the BHC treatment gave adequate protection to the new crop. The potatoes produced by the DDT-treated seed pieces were almost as heavily damaged as those produced in the untreated check row. The BHC-treated pieces gave only 23 per cent emergence and the few tubers that resulted were readily attacked although much less severely than those of comparable age in the other rows.

Table 3: Yield of potatoes and damage by wireworms to tubers produced from seed pieces treated with BHC and DDT.

Treatment	Total Tubers	Av. Wt. per hill (ounces)	Percentage of tubers with the following no. of tunnels per tuber					Av. no. tunnels per tuber
			0	1	2-4	5-9	10 (or more)	
			ALL TUBERS					
BHC	17	9.2[1]	71	23	6	0	0	0.3
DDT	100	16.5	35	21	30	11	3	2.1
Check	137	28.3	28	18	34	19	1	2.5
			TUBERS 2 INCHES OR MORE IN DIAMETER					
BHC	9	7.7	56	33	11	0	0	0.5
DDT	71	15.0	28	24	30	14	4	2.4
Check	100	26.5	22	18	34	24	2	2.9
			TUBERS LESS THAN 2 INCHES IN DIAMETER					
BHC	8	1.5	88	12	0	0	0	0.1
DDT	29	1.5	52	14	31	3	0	1.3
Check	37	1.4	43	19	33	5	0	1.4

[1]Based upon the 7 hills that produced tubers; this figure would read 2.1 if calculated from the 30 hills that were planted.

PRACTICAL SIGNIFICANCE OF THE RESULTS

On the basis of the preliminary investigation reported herein, DDT appears to have no practical value for wireworm control in the Prairie Provinces.

Crude BHC proved worthless in this test when used as a seed-piece treatment, principally because of its inhibiting effect on sprouting. This effect might be avoided by a lower concentration of BHC, or a lighter application, without an appreciable reduction in the protection from damage to developing tubers. Since the effect may be caused by impurities in the material used, further tests should be conducted with pure gamma isomer as soon as it is available.

As a soil treatment, crude BHC promises to be the first really practical method for the chemical control of wireworms in the Prairie Provinces. Unpublished investigations of the Saskatoon laboratory indicate that it is effective under nearly all soil, moisture and temperature conditions encountered in crop land. Tainting of produce, especially potatoes, grown on treated land, at least in the first two years following application of the chemical, is its most objectionable feature and this must be remedied before potato growers will use it generally. Until a preparation of BHC, which does not taint produce, is available, it cannot be recommended for use during the potato crop year or in the preceding year. Because of the taint factor the use of BHC for control of wireworms in land for potato production is advisable only if the chemical can be applied two or three years in advance of planting potatoes. In this interval summer fallow and crops which are not susceptible to taint can be used in the rotation. Our experience indicates that when wireworms are eliminated in a field they will not increase sufficiently in three years to cause serious damage.

It is suggested that the chemical be applied at from 0.5 to 1.0 pounds gamma isomer per acre in April or May of a summer fallow year, but it may also be applied during a cereal crop year if this fits in better with the rotation plan. It can be broadcast on the soil surface with any boom crop duster or sprayer, and immediately worked in to a depth of at least four inches with a plough or one-way disk. If BHC preparations can be applied with a fertilizer attachment for a plough or one-way disk the spreading of the insecticide can be combined with the tillage operation at virtually no

added cost for labour. The insecticide can also be applied with the dispensers (1, 7) developed for the application of liquid soil fumigants, at little extra cost for labour. Reliable estimates of cost of materials can not be given at present, but on the basis of reports received it should not exceed ten dollars per acre. This is less than half the cost of crude naphthalene or liquid fumigants.

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THE DURRA STEM BORER *Sesamia cretica* Led. A NEW PROBLEM IN IMPORTED EUROPEAN BROOM CORN*

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Importations into North America of shipments of broom corn (*Sorghum vugare* var. *technicum*) have always been a source of anxiety to plant quarantine officials. It is well known that the European corn borer, *Pyrausta nubilalis* Hbn., was almost certainly introduced onto this continent in this commodity (22), a surmise which receives perennial support from the continued finding of this species in consignments from various parts of Europe. Broom corn is usually imported in bales weighing from 100 to 250 pounds each, (Figures 1 and 2) which contain both the brush and anything up to 12 inches of stalk necessary for the proper binding of the broom. It is interesting to note that in the country of origin, after the broom corn is harvested, it is dried and cured and is then usually subected to the fumes of burning sulphur overnight in a closed room in order to bring about, through bleaching, a uniform yellowish colour desired in the trade. None of these treatments have any appreciable effect on the populations of living borers found in the stalks. In addition to insect pests which feed in or on broom corn as a normal host, other species may use the borings of the normal pests as sites of hibernation or pupation. Under some conditions, no doubt, stalks may be left lying in the field for some time prior to harvesting, and thus constitute a refuge for many potential pests.

Under ordinary conditions the corn is exported soon after removal from the field, thus affording an ideal medium for the rapid transport of the insects from one continent to another. Moreover, broom corn may be ranked as a "speculative" commodity, the purchase of which in Europe or South America depends on the price and availablity of the North Ameri-

*Contribution No. 68 from the Plant Protection Division, Science Service, Department of Agriculture, Ottawa, Ont.

can crop, which is grown mainly in the southeastern States. In some years there may be a sudden and heavy demand for broom corn grown outside this continent, with the consequent movement of large shipments, recently harvested and dried, with their attendant populations of insect pests. It must be emphasised that here we are not dealing with cosmopolitan insects, which have been widely distributed throughout the world in grains and stored products, from time immemorial. We are concerned with strictly agricultural pests which can be transported, without a break in the life cycle, from their native heath to broom factories, many operating on a small scale in towns and villages throughout the Dominion, some as integral parts of farm family enterprises and nearly always in the immediate vicinity of growing crops.

Prior to 1939 importations of this commodity into Canada originated in the Argentine or Hungary. From the former came broom corn containing larvae of species of *Diatraea,* and from the latter, shipments heavily infested with larvae, pupae and adults of *Pyrausta nubilalis* Hbn. From time to time, also, other species of insects were recovered which were not, apparently, primarily connected with broom corn.[a] The shipments were usu-

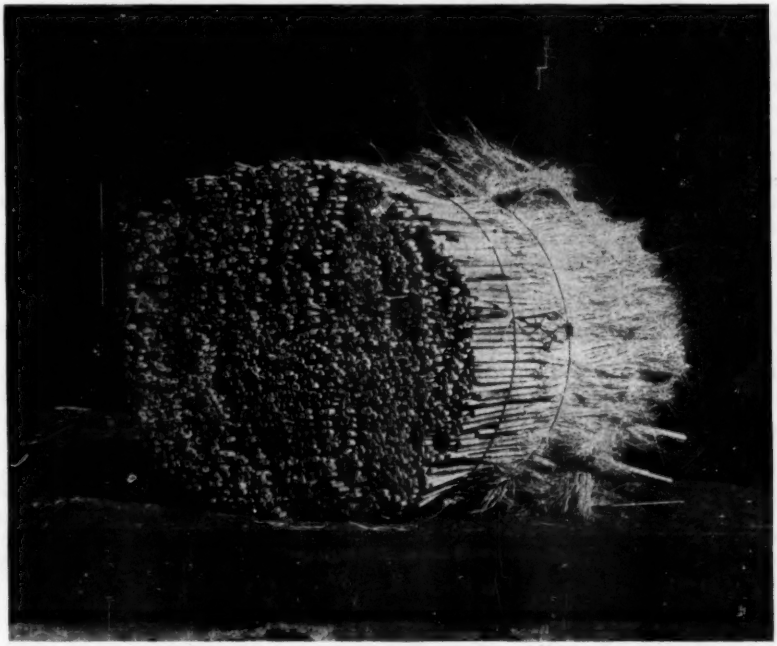

Figure I.

[a]For example, a list of what might be considered "agricultural pests" found in Hungarian broom corn during 1938-1939 includes the following:

HYMENOPTERA, Tenthredinidae.

Athalia colibri, Christ. Adults. Feeds on cruciferous plants.

Athalia lineolata, Lep. Adults. Feeds on *Ajuga, Capsella, Lycopus, Melampyrum, Plantago, Sedum, Veronica,* and *Scutellaria.*

Ametastegia equiseti, Fall. Adults Feeds on *Equisetum.*

Ametastegia glabrata, Fall. Adults. Feeds on *Rumex, Polygonum* and *Viola.*

Allantus calceatus, K. Adults. Feeds on *Spiraea, Rosa,* and *Fragaria.*

Priophorus sp. possibly *brullei* Thoms. Adults.

ally fairly small and could be handled conveniently by the vacuum fumigation equipment operated by the Plant Protection Division in Montreal.

From 1939 to 1946, European consignments were not available, and large shipments appeared from Argentine at irregular intervals. Due, apparently, to the fact that this latter material had been stored for varying intervals of time prior to shipment, no living insects were recovered after inspection at the various ports of unloading, and precautionary fumigations with methyl bromide in steel box cars of the approved type was permitted as a wartime emergency.

In June, 1946, importations of European broom corn were resumed for the first time since 1939. To date, this material has come exclusively from Italy owing to unsettled conditions in other parts of the continent. From June, 1946 to January, 1947 no living insects were recovered, and it was assumed that only material which had been in storage for some time was involved. On January 24th, 1947, broom corn of Italian origin arriving in Montreal via the port of New York was found to contain some lepidopterous larvae which, although dead, were in a state of preservation which indicated that they had recently been killed by exposure to cold. The temperature in the bales of broom corn at this time was 18 degrees F. These larvae were subsequently identified as belonging to the species *Sesamia cretica,* Led., commonly known as the "Durra stem borer", a determination which was later confirmed from living material collected during the following four months, and reared through to the adult stage. Larvae of the European corn borer were also present in these shipments. Living larvae and, in the late spring, a few adults continued to be intercepted in importations of this commodity until June, 1947, after which date only empty pupal cases were found, indicating that the population of the previous season in Italy had completed the life cycle and emerged as moths before reaching this country.

PERTINENT INFORMATION CONCERNING *Sesamia cretica,* Led.

A summary is given of relevant information on this insect, much of which was obtained from references in the Review of Applied Entomology, Agricultural Section.

Systematic Status: *Sesamia cretica* belongs to the family Noctuidae and the subfamily Hadeninae. It does not occur in our North American fauna, but is closely related in structure to the army worm *Leucania unipuncta* Haw., and to the zebra caterpillar, *Ceramica picta* Harris. Description: The adult is a typical Noctuid moth in size and general appearance. The forewing is pale coloured, yellowish ochreous, and in some specimens a row of small inconspicuous black dots can be seen 3 to 4 millimetres from the terminal margin of the wing. The hindwing is uniformly white. The larva is fleshy, with a pinkish to reddish tinge dorsally with pale yellow colouration beneath black spiracles, and when fully grown is 25-27 millimetres in length.

Hosts: This insect is recorded (2, 10, 12, 15) as feeding on varieties of *Sorghum vulgare* including *Sorghum vulgare* var. *technicum* (broom corn). Species of *Zea* (maize) are also attacked. From the literature it is concluded that preference for maize or sorghum varies according to locality.

Distribution: *Sesamia cretica* is reported from countries bordering on or adjacent to the Mediterranean sea as follows:

Italy (a serious pest in all parts) (6, 12, 13, 20);
Southern Yugoslavia (Dalmatia) (10); Crete (21);
Bulgaria (5); Syria (21); Iraq (8); Egypt (7);
Sudan (2); Algeria (19). It has recently appeared
in the South of France (4).

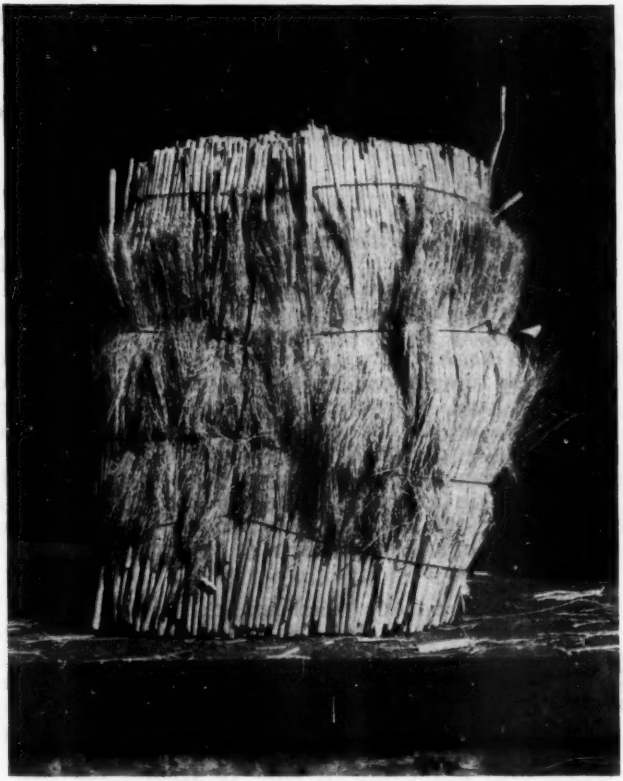

Fig. 2

Bionomics: In Italy, according to Cuscianna (6) the insect overwinters in the larval form and transforms to pupa and adult in the late spring and early summer. Incubation of the egg takes 8-10 days and the larval stage averages 40 days. In this way a second generation of larvae appears in the latter part of August. Overwintering larvae were destroyed by temperatures of 17 to 19 degrees F. in January and February.

Economic Importance: In the region of Trieste, Italy, Cuscianna (6) states that 80 per cent of the stalks may be infested. Hergula (10) reports that in Southern Yugoslavia the insect is of more economic importance to maize than *P. nubilalis*, as the larvae are larger and cause more injury in view of their habit of attacking both ears and grain. From the references cited above on distribution it appears that *S. cretica* is of great economic importance throughout its range, in some countries rivalling and even exceeding *P. nubilalis* in its depredations on *Sorghum* and *Zea*.

Control: In the Sudan, Bedford (2) reports that exposing cut stalks to the sun, in a thin layer, destroys most of the larvae and pupae.

In Italy, Cuscianna (6) recommends that infested stalks should be burned or fed to cattle before the end of April. According to Malenotti (12) with sugar sorghum, as the stalks are harvested early, it is sufficient to plough the stalks into the ground.

Related Species: The genus *Sesamia* is of Old World origin, and other species are of economic importance as pests of sorghum, maize, rice, wheat and related crops. *Sesamia vuteria* Stoll. (*nonagriodes* Lef.) appears to have a somewhat wider distribution in "temperate" climates than has *S. cretica*, being additionally reported from Spain and Portugal (9, 14), but there is no reason to suppose that records of *cretica* in such countries as Bulgaria are due to confusion with *vuteria*.

POSSIBLE THREAT IN CANADA

From the information available on this insect it would appear that *S. cretica*, in its native habitat, is mainly confined to countries with a Mediterranean type of climate. Two countries listed above, Bulgaria and the Anglo-Egyptian Sudan strictly speaking, lie outside the Mediterranean area. The Sudan, according to Kendrew (11), constitutes, climatically, a transition region between the dry Sahara and the tropical rain forest and is characterised by a rainy summer and a well marked drought in winter. Bulgaria, on the other hand, experiences comparatively severe winters of the Spanish Meseta type, and in the agricultural regions of the valley of the River Maritsa, a winter climate is experienced which, from the data presented graphically in Figure 3, would appear to be only slightly less severe than that experienced in southwestern Ontario and the Niagara Peninsula, and rather more severe than that in Vancouver and the lower Fraser Valley. The data for the mean annual extremes of low temperatures are also of value for comparative purposes.

The observation, previously mentioned, that larvae arriving in Montreal were found to be dead in bales with temperatures of 18 degrees F., coupled with the statement of the Italian worker Cuscianna (6) that larvae succumbed at temperatures of 17 to 19 degrees F., gives definite evidence of a climatic check on the survival of the hibernating larvae of this species, but there is at present no published data on the length of exposure required to kill the larvae at these temperatures. Moreover, before any conclusion is drawn from this record, it must be pointed out that the bales in question were fully exposed to outside winter temperatures during transit periods of one week or more, in the railroad cars, while under natural conditions hibernating larvae would be covered with the usual blanket of snow, vegetation, trash or debris. If for no other reason, the record in a country with a well defined winter would justify the carrying out of all measures necessary to prevent the temporary or permanent establishment of this insect in Canada. Furthermore, there is no doubt that this species could become a serious pest in the corn and sugar growing areas of the Southern United States, so that a local outbreak anywhere in North America, however temporary, might constitute a source of infestation for these other regions.

CONTROL MEASURES UNDERTAKEN IN CANADA

In an earlier paper (16) the writer had shown that, under experimental conditions, the European corn borer could be killed with methyl bromide at greatly increased concentrations at temperatures as low as 26 degrees F. when placed artificially in bales of broom corn. It was fully realised at the time, that further conclusions as to the effectiveness of this type of treatment would have to await further trials under practical conditions, with the observations based on commodities with natural infestations rather than those stocked with artificially introduced test insects. The fin-

ding of *S. cretica* together with larvae of *P. nubilalis* provided the first opportunity to observe the effectiveness of atmospheric fumigations at low temperatures on naturally infested broom corn.

As the capacity of the vacuum fumigation plant operated by this Department was insufficient to deal with the amount of broom corn being shipped at this time, the importers were permitted to attempt atmospheric fumigation in railroad cars and to arrange for these to be placed in a heated railway workshop for 24 hours before being brought out into the open for fumigation. This warming process had the effect of raising the commodity and car temperatures to between 40 and 50 degrees F., at which temperatures it was hoped that these treaments might be successfully carried out.

As a result of the experimental work previously described, a tentative schedule for box car fumigation with methyl bromide had been drawn up, requiring dosages for overnight exposures of 16 hours at 4 pounds per thousand cubic feet at 45 to 50 degrees F., and 4.5 pounds for 40 to 45 degrees F. Using the pan method of evaporating the liquid methyl bromide from pans as previously described by Bellemare (3), this treatment was found, when tried late in January 1947, to be inadequate against the larvae of *P. nubilalis* and produced an interesting condition with the larvae of *S. cretica*. In the latter case, as previously mentioned, a number of these had apparently succumbed to the cold temperatures in the region of 18 degrees F. prevailing at that time, but living larvae were also collected prior to fumi-

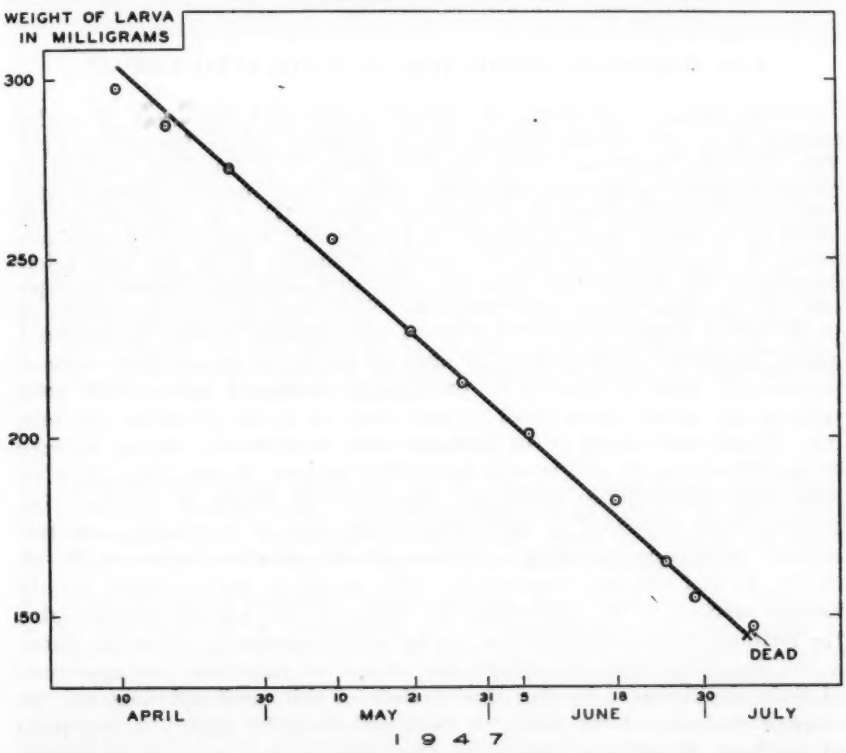

FIG. 4

gation. Following treatment all the larvae of this latter species appeared at first inspection to be dead, but examination of some individuals under the binocular microscope revealed that the dorsal blood vessel was still vigorously pulsating. Moreover, although these insects were incapable of locomotion, they reacted to gentle pricking of the caudal segments of the abdomen by slight movements of these parts. Accordingly, the fumigation treatments were repeated when necessary and the schedule provisionally increased to 48 hours duration at dosages of 6 and 6.5 pounds per thousand cubic feet for the two temperature ranges previously described. With material arriving during the cold weather in February, when outside temperatures were sometimes as low as zero degree Fahrenheit, this treatment was at first thought to be effective, but moribund larvae of *S. cretica* in the condition described above, continued to be recovered. Finally, when outside temperatures rose to around 32 degrees F. and heating facilites were not available, vigorous survivors of both species were recovered in these fumigations, and the dose of methyl bromide was increased to 9 pounds per thousand cubic feet for temperatures between 32 and 50 degrees F., with a similar exposure period of 48 hours. This final schedule was found to be completely effective in twenty box car treatments in up-to-date Canadian steel cars of the approved type (18) each with a capacity of 3712 cubic feet, containing 200 bales of broom corn weighing 10 short tons, with commodity temperatures varying between 32 and 50 degrees F. From the twenty cars in question, complete mortality was recorded with the collection of larvae removed from stalks after fumigation, represented by 149 *S. cretica* and 62 *P. nubilalis.*

THE MORIBUND CONDITION OF FUMIGATED LARVAE

The delayed mortalities of insects exposed to lethal doses of methyl bromide is a well known phenomenon to workers in the fumigation field. The "nervous" condition of hibernating larvae of *P. nubilalis* exposed to methyl bromide fumigations following removal from outdoor winter storage conditions was mentioned in a previous paper (17). In the case of the larvae of *S. cretica*, those fumigated in January and February had been subjected to temperatures at least as low as 20 degrees F. in the bale before treatment, and during this time the moribund conditions following exposure, as described above, were observed. Nine such larvae were noticed to be in such a condition out of a total of 150 collected during the post-fumigation inspection. These were all observed to be in an excellent state of preservation, slightly sensitive to pricking as mentioned above, with pulse rates of the dorsal blood vessel varying from 21 to 43 pulsations per minute. These were placed in an incubator with temperatures varying between 72 and 78 degrees F., and relative humidities between 70 and 76%. Observations were made on loss of weight, pulse rate and length of survival. The survival times expressed in days between the date of fumigation and subsequent death were recorded as follows for six of these larvae as 28, 50, 58, 75, 81 and 140 days respectively. The record in loss of weight for the longest survivor is also illustrated in Figure 4. It will be observed that the relationship between time and loss of weight appears to be strictly linear, as the deviations from the straight line, drawn by inspection, are apparently of little significance. Another characteristic of this moribund state was the extreme flaccidity of the body. A larva picked up by forceps at any point of the body would hang limply on either side of such point of suspension.

FIG. 5

Of ten larvae only two attempted to progress to a more advanced stage. One tried to moult into a further larval instar but was unable to cast the skin, while a blackish fluid appeared between the old and the new cuticles. Portions of the old cuticle were removed with forceps, when the larva was found to be in the typical moribund state and died after ten days. Another mature larva attemped to pupate, but only succeeded in attaining a condition in which the head and thorax remained larval in form but developed, underneath the old uncast skin, a hard brown cuticle of the pupal type. The abdomen remained mainly larval in form, but a new hard brown cuticle was formed under the old, uncast skin which possessed, on the anterior half of each segment, the typical puctures found on the pupal cuticle. This insect, illustrated photographically in Figure 5, died one day after reaching the condition described.

SUMMARY

1. Lepidopterous larvae found for the first time in importations into Canada of Italian Broom Corn were determined as belonging to the species *Sesamia cretica* Led., commonly known as the Durra stem borer, an insect found in lands surrounding, or near to, the Mediterranean Sea.

2. A review of the literature concerning this insect indicates that although larvae are reporting as succumbing to low temperatures in the region of 17 degrees F., there is no reliable data on the length of exposure required to bring about this effect. There is, thus, no justification for assuming that this species could not become either permanently established in some parts of Canada or cause temporary outbreaks which might set up foci of infection of possible threat to the corn and sugar growing areas in the Southern United States.

3. It was found that living larvae of *S. cretica* and *Pyrausta nubilalis* Hbn. inside the stalks of broom corn could be controlled in approved types of Canadian steel railroad cars of 3712 cubic feet capacity, when bale temperatures were as low as 32 degrees F., by employing 9 pounds of methyl bromide per thousand cubic feet with exposure periods of 48 hours, with loads of 200 bales weighing approximately 10 short tons. A condition of delayed mortality of fumigated hibernating larvae of *S. cretica* is described, in which one individual survived for as long as 140 days following exposure to the fumigant.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the great assistance in the work described in this paper rendered by Mr. G. L. Giasson, Senior Inspector, Division of Plant Protection, Montreal, P.Q., who supervised the inspection and fumigation of the imported material. Mr. Giasson was helped at various times in this work by Mr. N. Cameron, Senior Inspector, and Messrs. E. A. True and P. Taché, Inspectors. Thanks are due to Drs. T. N. Freeman and O. Peck of the Systematic Unit of the Division of Entomology, Department of Agriculture, Ottawa, for supplying determinations and information regarding the insects described in this paper. Acknowledgement is made to Mr. L. B. Jameson, In Charge of Illustrations, Science Service, Department of Agriculture and his assistants, Messrs. L. St. Laurent and F. Gusella, for the making and preparation of the photographs and figures. Meteorological data for Bulgaria was kindly supplied by Mr. A. J. Connor, Meteorological Division, Department of Transport, Toronto, Ont. The diagram for Figure 3, was kindly made by Mr. H. G. Carmody of the Toronto office of this Division.

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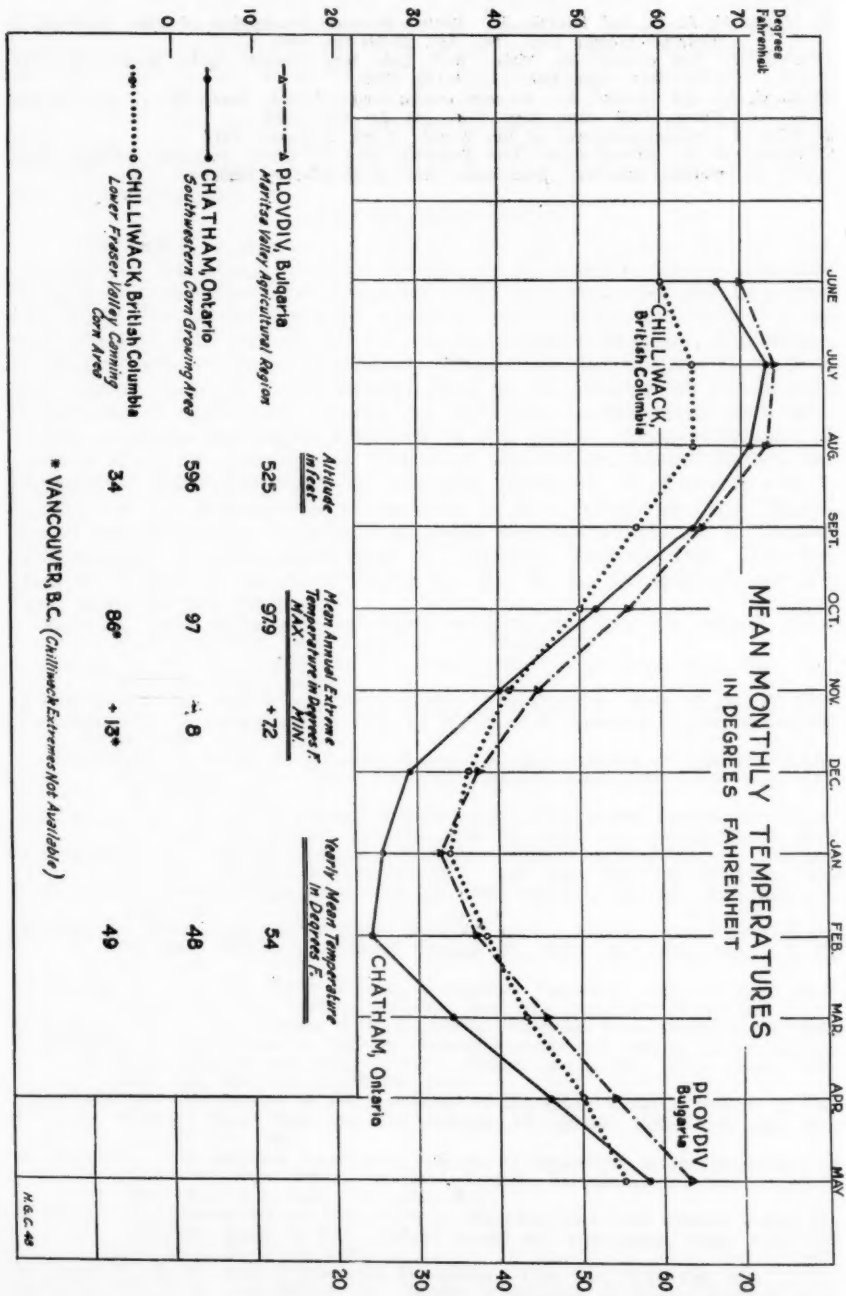


Figure 3. Comparison of winter temperatures in agricultuaral area of Bulgaria with two of the warmer regions in Canada where corn is grown.

FIELD IDENTIFICATION OF POTATO APHIDS[1]

BY LEO A. DIONNE
Dominion Entomological Laboratory, Fredericton, N. B.

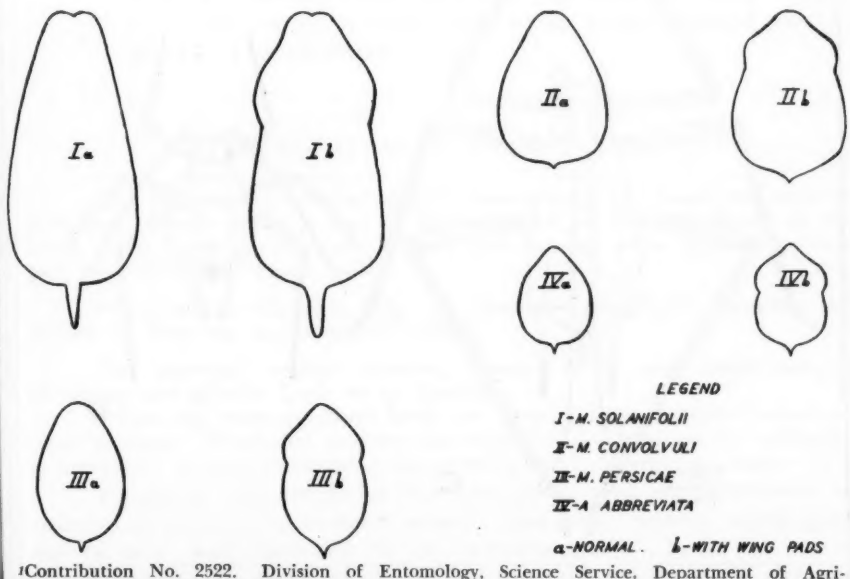
During the summer of 1947, the potato inspectors (Dominion Division of Plant Protection) working in New Brunswick and Nova Scotia were given a course in potato aphid identification based on the methods presented herewith. In nearly all cases a high degree of accuracy was achieved in a few hours of practice. The purpose of this course was to aid the inspectors in determining the potential number of leaf roll vectors present. This paper is given with the hope that the method may be of value to others similarly interested.

Elaborate keys have been devised by aphid taxonomists which in the hands of the experts are as nearly foolproof as keys can be. However, these keys are much too involved to be used for the large scale identification of such a restricted group of insects as the potato aphids. The four species of potato aphids* may be accurately separated on the basis of gross characteristics, visible to the naked eye. However, it is advisable to use a good hand lens to check the accuracy of one's diagnosis, at least until sufficient experience has been attained to establish the confidence of the worker in the accuracy of the method.

The following key has been devised for the identification of wingless aphids, since these comprise the majority of these insects found in potato fields during the summer. The key characters in bold type are visible to the naked eye, those in italics require the use of a hand lens.

Green peach aphid, *Myzus persicae* Sulzer
Buckthorn aphid, *Aphis abbreviata* Patch
Foxglove aphid, *Myzus pseudosolani* Theobald
(=*convolvuli* Kaltenbach)

IMPRESSION OF BODY OUTLINES

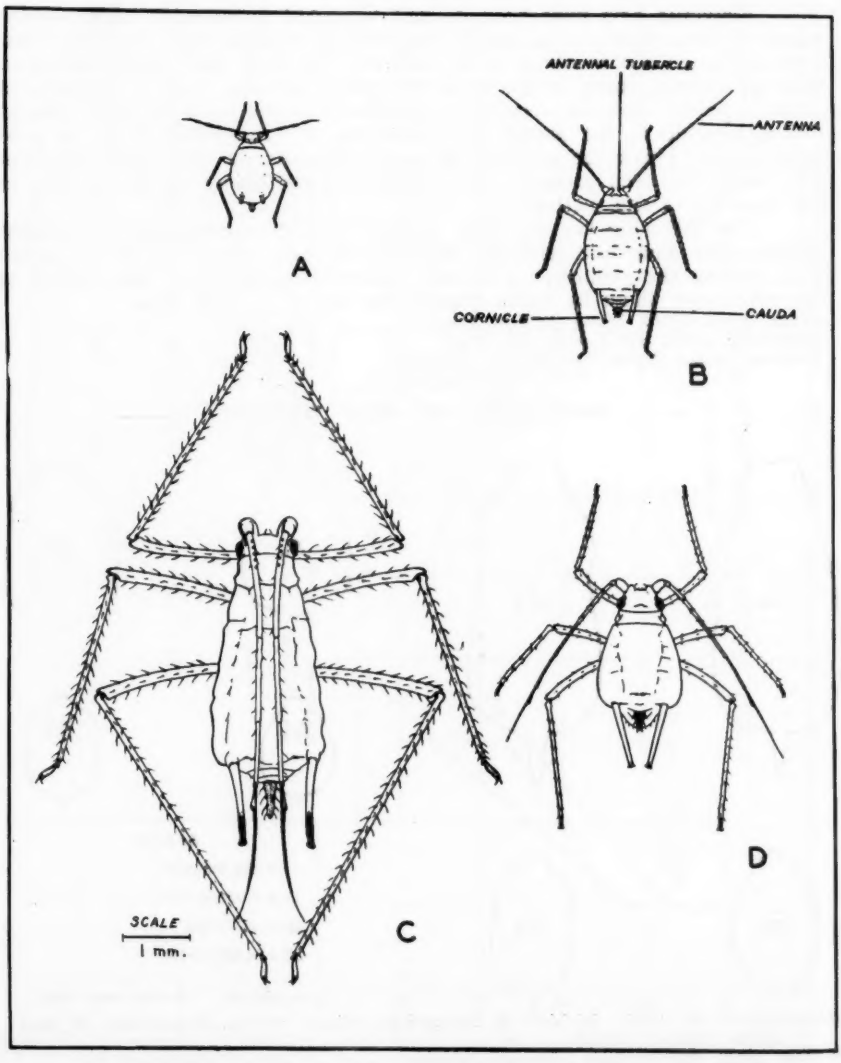


[1]Contribution No. 2522. Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

*Potato aphid, *Macrosiphum solanifolii* Ashmead

A KEY FOR FIELD IDENTIFICATION OF POTATO APHIDS

*1. (a) Body shape, rounded (ovoid, pear or almond shaped) 2
(b) Body, wedge shaped and elongated: Colour, any except black, usually some shade of green but red, brown, yellow, orange and even purple forms are found. A prominent darker coloured dorsal ridge is generally present. In the adult, the cornicles and cauda are plainly visible to the naked eye. The legs are long and prominent. This species is found in greatest abundance on the upper portion of the potato plant. The largest of the potato aphids....



..... *Macrosiphum solanifolii* Ashmead
Head shape is characteristic (see diagram II, Figure C) cornicles cylindrical, antennae very long, much longer than the body. Cauda about half the length of the cornicles.

2. (a) Body thick, pear or almond shaped 3

(b) Body flattened ovoid. Colour greenish yellow, or very dark, opaque leaf green. In the autumn many are black. A small sluggish aphid usually found in greatest abundance in the middle and bottom sections of the plant ..... *Aphis abbreviata* Patch. *No prominent tubercles present at the base of the antennae, anterior edge of head apparently straight. Cornicles reduced to mere stubs.*

3. (a) Abdomen widest in midsection, colourless, light blue green or red, if any yellow pigment is present it is combined with red, producing a peach colour, yellow is rarely combined with green or blue on potato plants. The adult is a medium sized aphid *Myzus persicae* Sulzer. *The antennae spring from comparatively large in-pointing antennal tubercules, giving the head its characteristic shape (see diagram 2 Figure B). The cornicles are medium long and usually slightly bulging in the middle. The cauda is quite short but distinct from the last segment of the abdomen.*

3. (b) Abdomen widest at the base: light green, yellow green or a clear dark green. Younger instars have many rusty red patches at the base of the abdomen. These sometimes persist in the adult. The adult aphid is larger than *M. persicae* but smaller than *M. solanifolii* .... *Myzus convolvuli* Kaltenbach. *The antennal tubercules are smaller than those of persicae, the cornicles longer, of a very pale color and always cylindrical. The cauda is blunt and barely extends beyond the last segment of the abdomen.*

INTERPRETATION OF CHARACTERISTICS

The difference in outline of *abbreviata* on the one hand and *persicae-convolvuli* on the other is due to the difference in the proportions of the heads. The head of *abbreviata* is small and narrow, while those of *persicae* and *convolvuli* are rather wide.

When present the dark ridge of *solanifolii* immediately identifies this species; as does also its elongated outline.

The rounded outline, flatness, opaque colors and small size of *abbreviata* are reliable leads to its identity.

When the rusty coloured spots are present these separate *convolvuli* from *persicae*. When not present the width of the base of the abdomen, as compared to the midsection, may readily serve to separate them.

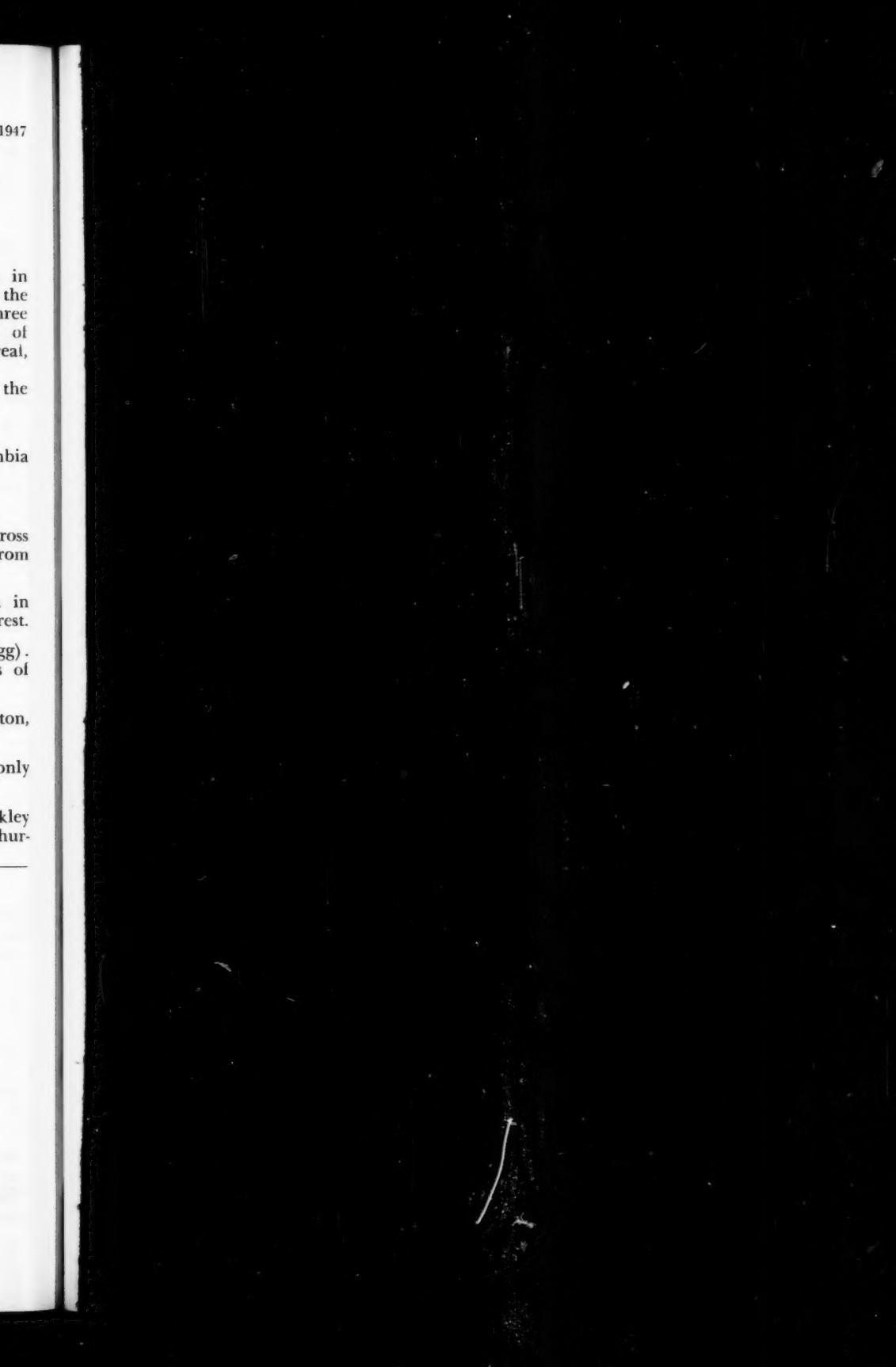
Familiarity with the above key characters is most readily achieved by examination of colonies, as these normally have adults present, which forms are the most easily identified by the inexperienced.

**Body shape of some insects modified in midsummer and autumn by the appearance of wing pads (see diagram I).

RECORDS OF THE SPECIES OF NYSIUS OCCURRING IN THE DOMINION OF CANADA (*HEMIPTERA : LYGAEIDAE*)

BY H. G. BARBER,
Roselle, N. J.

The author published recently a "Revision of the Genus *Nysius* in the United States and Canada."* In compiling the data pertaining to the distribution of the species in Canada much assistance was rendered by three entomologists: Mr. G. Stuart Walley, Entomologist of the Department of the Department of Agriculture, Ottawa; Mr. George A. Moore of Montreal, Que. and Mr. J. F. Brimley of Wellington, Ont.
it seems advisable to publish a summary of that part dealing with the distribution of the several species, so far known, from the Dominion. These are as follows:

1. *Nysius californicus* Stal. Alberta (Coaldale); British Columbia (Victoria).
2. *Nysius californicus alabamensis* Baker. Ontario
3. *Nysius angustatus* Uhler. Taken in numerous localities across Canada from Quebec to British Columbia; not yet known from Nova Scotia and North West Territories.
4. *Nysius ericae* (Schilling). This Palaearctic species is common in all of the provinces and is the only species of economic interest.
5. *Nysius grandis* Baker. Manitoba (Churchill); Alberta (Noregg). This species should also be found in the mountainous regions of British Columbia.
6. *Nysius tenellus* Barber. British Columbia (Goldstream, Penticton, Royal Oak, Saanich District).
7. *Nysius thymi* (Wolff). Another Palaearctic species collected only in Quebec (Natashquan, Thunder River).
8. *Nysius groenlandicus* (Zett.). Prince Edward Island (Brackley Beach, Dalvay House); Quebec (Bradore Bay); Manitoba (Churchill).

*Journ. Wash. Acad. Sci., XXXVII, Oct. 15, 1947, 354-366.